Splinting for the prevention and correction of contractures in adults with neurological dysfunction

Practice guideline for occupational therapists and physiotherapists

College of Occupational Therapists and
Association of Chartered Physiotherapists in Neurology

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APPROVED BY
CHARTERED SOCIETY OF PHYSIOTHERAPY

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College of Occupational Therapists
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This guideline was developed using the processes defined within the Practice guidelines development manual (College of Occupational Therapists [COT] 2011a).

Readers are referred to the manual to obtain further details of specific stages within the guideline development process.

The manual is available at: http://www.cot.co.uk/sites/default/files/publications/public/PGD-Manual-2014.pdf

Foreword

Disability and loss of independence following an acquired neurological injury presents a significant global health and social care problem. In the last decade there have been significant advancements in public health education and medical management that has resulted in better outcomes for many of these patients; primarily more patients are being kept alive. However, these improvements appear to have had very little impact on the prevalence of disability in the community.

It is generally agreed that recovery of functional activity and societal participation depends primarily on the rehabilitation therapies offered (e.g. physiotherapy, occupational therapy, speech and language therapy, etc.). If rehabilitation is to be effective, the programmes of therapy will have to be customised to the needs of the patient and initiated as soon as possible after the initial injury. A tacit focus of current neurological rehabilitation strategies is maximising plasticity within the central nervous system, and rightly so. However, what can often be forgotten is that the musculoskeletal system is just as plastic and deterioration in the form of muscle wastage, adaptive changes in length and stiffness (contractures or fixed flexion deformity) and joint deterioration can occur. The current evidence is unequivocal in demonstrating that current practice is not effective in preventing these musculoskeletal complications. Whilst focusing neurological rehabilitation on facilitating neural recovery and preventing spasticity is important, it is equally essential that steps are taken to prevent and, if needed, treat the detrimental changes associated with maladaptive musculoskeletal plasticity.

There is a paucity of research into the management (prevention and treatment) of maladaptive plasticity in muscles. However, the guideline development team has brought together a document that should inform clinical practice and research. The title of this guideline suggests a focus on a single method of treatment (i.e. the use of splints). However it is far more comprehensive than this. The definition of '*splinting*' used within the guideline '… *a term used to describe the process of applying a prolonged stretch through the application of a range of devices*' has ensured that the authors have included in their review most common methods that can play a role in the management of maladaptive musculoskeletal plasticity.

The decision to offer any form of rehabilitation (or not as the case may be) is a crucial one, especially when the available resources are significantly restricted. Whilst it might be required to offer all patients who have a need, in reality this may not happen. If the decision is to offer rehabilitation then it is crucial to ensure that the patient receives a package of care appropriate in terms of content, quantity and resources to facilitate the recovery process. If the decision is not to offer rehabilitation, then it is equally crucial that this decision is taken carefully as the denying of rehabilitation will automatically reduce the recovery potential of the individual. The authors have made significant efforts to discuss this complex issue of customisation in a practically relevant way.

What is obvious, from the Public and Patient Involvement (PPI) work undertaken as a part of this guideline, is that the rehabilitation being provided to patients is far from adequate and there are unmet needs in terms of contractures and related complications. It is hoped that this guideline will (a) increase the attention on the maladaptive changes occurring within the musculoskeletal system, (b) empower

clinicians to learn new skills that are at risk of dying before they have been fully tested, and (c) provide a stepping stone for future research aimed at preventing and treating the maladaptive changes in the musculoskeletal system of patients with acquired neurological conditions.

Professor Anand D. Pandyan
Professor of Rehabilitation Technology
School of Health and Rehabilitation & Research Institute for Keele University

Foreword

For the clinician interested in neurological rehabilitation 'to splint or not to splint' remains a challenging question. Given how common upper and lower limb contractures are, whether in the presence or absence, the lack of clarity has been frustrating. In some services, nearly all patients are splinted: in others, hardly any are splinted. This variation probably reflects the hidden complexity in the simple question 'Should we splint this patient?'

This guideline draws together the theoretical underpinnings, the available evidence, reflects service users' perspectives, and makes a series of recommendations. Perhaps, unsurprisingly, given the complexity, most of the recommendations are made in the form of suggestions rather than definitive statements. However, the link between evidence and recommendations is skilfully undertaken highlighting the relevant issues. The approach to splinting is developed through consensus but is clearly articulated, highlighting important issues. The authors emphasise that splinting should only be undertaken as part of the comprehensive multidisciplinary management of the patient, by appropriately skilled postgraduate practitioners, and additionally there is need for clear objectives, patient consent, measurement and review.

Perhaps the most important part of the guideline is the recommendations for future research. Fifteen areas are highlighted. Funding sources need to recognise the prevalence of contractures, the time they take to manage, their functional impact including pain, discomfort and difficulty with care, and prioritise this area.

Clinicians should read this guideline. The clinical reasoning underpinning the splinting of patients will be more clearly articulated as a result. Researchers and research funders should also read it. Improving the evidence base can only result in better and greater functional outcomes.

Dr Diane Playford
Reader in Neurological Rehabilitation, UCL
Consultant Neurologist, National Hospital for Neurology and Neurosurgery, UCLH Trust

Key recommendations for implementation

This practice guideline aims to provide specific recommendations to support clinical practice and decision-making in splinting when used as an intervention for adults with neurological conditions who have, or are at risk of, contractures. It is intended that the recommendations are used alongside the therapist's clinical expertise and, as such, the clinician is ultimately responsible for the interpretation of this evidence-based guideline in the context of the specific circumstances, environment and service users. This guideline does not provide practical information on how to undertake splinting.

The recommendations must be considered in conjunction with the contextual information provided in the rest of this document and the details on the strength and quality of the recommendations. It is strongly advised that Section 6 is studied together with the evidence tables detailing the outcome of the literature search in Appendix 7. Furthermore, the impact of the qualitative findings from the engagement with service users (Appendix 4), the results of the Delphi method survey of therapists (Appendix 3), and the overall availability of evidence should be considered carefully.

Recommendations are graded based on the **G**rading of **R**ecommendations **A**ssessment, **D**evelopment and **E**valuation (GRADE) process (Grade Working Group 2004), as described in the *Practice guidelines development manual* (College of Occupational Therapists [COT] 2011a). Recommendations are scored according to strength (1 (strong) 2 (conditional)) and are graded from A (high) to D (very low) to indicate the quality of evidence (see Tables 6.3 and 6.4). The 19 recommendations (divided into lower limb and upper limb categories) reflect the potential outcomes for therapists and service users when considering whether to provide or prescribe splints or casts for adults with neurological conditions for the prevention or correction of contractures and associated impairments.

Summary tables of recommendations

It is the view of the Guideline Development Group (GDG) that, taking into account the systematic review findings and the strength of the evidence, splinting interventions can have a role in overall prevention and correction of contractures. Nonetheless, therapists must be analytical and critical in their splinting practice, identifying when splinting may be applicable and when not. The GDG agrees with the recommendations made in other guidelines, such as the *National clinical guideline for stroke* (Intercollegiate Stroke Working Party [ISWP] 2012), that splints for the wrist and hand should not be used routinely after stroke. This does not mean, however, that splinting (splints or casts) has no role, and it is advocated that it should be considered for the wrist and hand in selected cases. The aforementioned guidelines are based on the evidence from stroke. This guideline adds to this literature from the wider field of neurorehabilitation.

'The splinting of my arm was great – it made sleeping easier as it stopped me digging my own finger nails into my palm and waking me up.' (Service user)

Lower limb

Recommendations are graded A (high) to D (very low) to indicate the quality of the evidence, and the scoring of 1 (strong) or 2 (conditional) indicates the strength of the recommendation.

Ankle: contracture correction		
1.	It is suggested that ankle casts are used at end range (for people with ABI and stroke) for improving range of movement at the ankle joint. *(Booth et al 1983 [D] ABI; Carda et al 2011 [B] stroke; Lehmkuhl et al 1990 [D] ABI; Moseley 1993 [C] ABI; Moseley et al 1997 [B] ABI; Pohl et al 2002 [C] ABI and stroke; Singer et al 2003a [B] stroke and ABI; Singer et al 2003b [C] stroke and ABI; Verplancke et al 2005 [B] ABI; Yasar et al 2010 [D] stroke)*	2C
2.	It is suggested that ankle casts are applied at end range to improve joint range of movement in conjunction with botulinum toxin A (in people with stroke and ABI) when presenting with clinically significant spasticity (see also RCP 2009). *(Carda et al 2011 [B] stroke; Farina et al 2008 [B] stroke; Verplancke et al 2005 [B] ABI; Yasar et al 2010 [D] stroke)*	2B
3.	It is suggested that adjustable ankle splints applied at end range can be used (in people with stroke and ABI) for improving joint range of movement. *(Grissom and Blanton 2001 [D] stroke and ABI; Lai et al 2008 [C] ABI and stroke)*	2C
4.	It is suggested that caution is exercised when considering the use of non-custom-made splints for the correction of contractures (at the ankle in people with stroke and ABI) due to the risk of pressure sores. *(Grissom and Blanton 2001 [D] stroke and ABI)*	2D
Ankle: Contracture prevention		
5.	It is suggested that ankle casts at end range dorsiflexion (in people with acute ABI) can prevent loss of range of movement. *(Conine et al 1990 [C] ABI)*	2C
6.	It is suggested that an ankle splint can be used for preventing the loss of range of movement at the ankle joint (in people with stroke) when positioned at plantar grade. *(Robinson et al 2008 [B] stroke)*	2B
7.	It is suggested that caution is exercised when considering the use of non-custom-made splints for the prevention of contractures (at the ankle in people with stroke) due to the risk of pressure sores. *(Robinson et al 2008 [B] stroke)*	2B

Lower limb

Recommendations are graded A (high) to D (very low) to indicate the quality of the evidence, and the scoring of 1 (strong) or 2 (conditional) indicates the strength of the recommendation.

Knee: contracture correction	
8. It is suggested that casts may be used for the correction of contracture (in people with ABI and stroke) with the knee joint positioned at end range of movement. *(Booth et al 1983 [D] ABI; Lehmkuhl et al 1990 [D] ABI; Pohl et al 2002 [C] ABI and stroke)*	2D
9. It is suggested that short-duration cast application (1–4 days) may produce a lower complication rate than longer-duration cast application (4–7 days). *(Pohl et al 2002 [C] ABI and stroke)*	2C
Knee: contracture prevention	
10. It is suggested that casts at end range of movement at the knee joint may be used (in people with stroke and ABI) for the prevention of contracture. *(Pohl et al 2002 [C] stroke and ABI)*	2C
11. It is suggested that caution is used when considering casts for acute patients (with ABI and stroke) and at lower levels of arousal because of possible risks of secondary complications (e.g. pressure areas). *(Pohl et al 2002 [C] stroke and ABI)*	2C

Upper limb

Recommendations are graded A (high) to D (very low) to indicate the quality of the evidence, and the scoring of 1 (strong) or 2 (conditional) indicates the strength of the recommendation.

Hand and wrist: contracture correction	
12. It is suggested that splints should not be used routinely for the correction of range of movement but may be beneficial in selected cases (in people with stroke and ABI). *(Abdolvahab et al 2010 [D] stroke; Amini et al 2009 [D] stroke; Beaty and Murphy 2013 [C] stroke; Bürge et al 2008 [A] stroke; Charait 1968 [D] stroke; Doucet and Mettler 2013 [C] stroke; Fayez and Sayed; 2013 [C] stroke; Lannin et al 2007a [A] stroke; Lannin et al 2003 [B] stroke and ABI; Leung et al 2012 [A] stroke and ABI; Shamila et al 2011 [D] stroke)*	2B
Hand and wrist: contracture prevention	
13. It is suggested that splints should not be used routinely to prevent loss in range of movement at the wrist and hand (people with stroke and ABI) but may be beneficial in selected cases. *(Basaran et al 2012 [B] stroke; Bürge et al 2008 [A] stroke; Harvey et al 2006 [A] stroke and ABI; Lannin et al 2007a [A] stroke; Lannin et al 2003 [B] stroke and ABI; Shamila et al 2011 [D] stroke)*	2B

14. It is suggested that splints in conjunction with botulinum toxin A (in people with stroke and ABI) may reduce spasticity as a component in preventing loss of range of movement in selected cases. *(Carda and Molteni 2005 [C] stroke and ABI)*	2C
15. It is suggested that electrical stimulation of wrist and finger muscles combined with a custom-made wrist and hand splint should not be used routinely to prevent loss in range of movement (in people with stroke or ABI). *(Leung et al 2012 [A] stroke and ABI)*	2A
16. It is suggested that a custom-made wrist and hand splint should not be used routinely to prevent the increase (or worsening) of spasticity (in people with stroke and ABI). *(Basaran et al 2012 [B] stroke; Bürge et al 2008 [A] stroke; Jung et al 2011 [C] stroke; Leung et al 2012 [A] stroke and ABI; Shamila et al 2011 [D] stroke)*	2B
17. It is suggested that a splint in a neutral wrist position may be beneficial (for people with stroke) for prevention of hand pain associated with joint malalignment. *(Bürge et al 2008 [A] stroke)*	2A
Elbow: contracture correction	
18. It is suggested that casts at end range are used (for people with ABI and stroke) for improving range of movement at the elbow joint. *(Hill 1994 [C] ABI; Lehmkuhl et al 1990 [D] ABI; Moseley et al 2008 [B] ABI; Pohl et al 2002 [C] ABI and stroke)*	2C
19. It is suggested that short-duration cast application (1–4 days) may produce a lower complication rate than longer-duration cast application (4–7 days). *(Pohl et al 2002 [C] ABI and stroke)*	2C

1 Introduction

This guideline has been developed to assist occupational therapists and physiotherapists with clinical decision-making when considering the process of splinting for contracture in adults with a neurological condition; it does not provide practical information on how to undertake splinting.

As stroke, multiple sclerosis (MS) and acquired brain injury (ABI) account for 80% of the diagnostic categories of adults admitted to rehabilitation services in the United Kingdom (Barnes and Rademacher 2003), these guidelines have been developed primarily drawing upon the literature from these clinical areas. In this guideline, the term **acquired brain injury** encompasses non-stroke clinical presentations such as traumatic brain injury (TBI), intracranial haemorrhage and arteriovenous malformation.

Contracture is a common secondary complication of paresis and weakness following nervous system damage (Lieber 2010). The inability to move joints through a full range of movement due to weakness is a primary contributor to contracture. To help people maintain their level of function and independence, muscles and joints must maintain their length and range of movement to limit the adverse effects of stiffness from secondary complications (Pitts and O'Brien 2008). **Contracture** is defined as a limitation in passive range of joint movement (Halar and Bell 1988). Contracture formation is complex, and a number of structures can be involved, including the joint capsule, joint ligaments, muscles and tendons (Farmer and James 2001). Contractures in the early stages of development have been described as having elements of thixotrophy and therefore being more adaptable to change. The term 'thixotrophy' has been applied to substances that can be changed from a gel-like substance to a solution after being stirred (Vattanasilp et al 2000). Muscle, although clearly not a gel or solution, has been described as behaving as a thixotrophic substance in that its stiffness depends on the history of limb movement. Lakie and Robson (1988) found that when stretch was applied to a relaxed muscle that had been maintained in a shortened position, initial resistance to movement was high. Conversely, with muscle in a lengthened position, the initial resistance was lower. Clinically an increased resistance to passive movement would be felt on initially moving a limb; after stretch has been applied, however, this relative stiffness is decreased. Over time, contractures may develop and the muscle is then less amenable to alteration.

In addition, the presence of positive signs of the upper motor neuron syndrome (UMNS) i.e. spasticity, can play a role in the development of non-neural adaptations seen with decreasing range of movement (Ada et al 2006, Kilbride and Cassidy 2011). Spasticity is defined as a disordered sensori-motor control resulting from an upper motor neuron lesion, presenting as intermittent or sustained involuntary activation of muscles (Pandyan et al 2005).

Splinting is an intervention used in the prevention and correction of contracture in adults with a neurological condition (Coppard and Lohman 2008, Edwards and Charlton 2002). Splinting is defined as the 'application of external devices designed to apply, distribute or remove forces to or from the body in a controlled manner, to perform one or both functions of control of body motion and alteration or prevention in the shape of the body tissue' (Rose 1986). The focus of this guideline is alteration or prevention in

the shape of body tissue. Splinting may be applied for the control of body motion by therapists or orthotists, but this is not covered in this guideline.

In the context of this guideline, the aim of splinting is to correct and prevent contractures and in doing so facilitate improved function through increased range of movement. The rationale underpinning splinting is to provide a prolonged stretch to maintain or promote change in a body structure (the theoretical basis of splinting is explored in more detail in Section 3). Depending on the rationale for splinting and the individual clinical presentation, splinting may be used in conjunction with other therapeutic adjuncts such as botulinum toxin or a regular standing programme. In some cases where contracture has become established resulting in fixed joint deformity, conservative means (i.e. splinting) are not sufficient to produce change where this is the goal. In these instances, it may be appropriate to consider surgical intervention; this does not fit within the remit of this document and will require referral to an orthopaedic surgeon. Following splinting or surgical intervention for contracture, long-term orthotic provision may be required for continued maintenance of joint range and function. Referral to an orthotist as part of overall multidisciplinary management is strongly recommended.

In this guideline, **splinting** will be the term used to describe the **process** of applying a prolonged stretch through the application of a range of devices. Most commonly, but not exclusively, a **splint** is made from thermoplastic material. In addition, prefabricated splints are sometimes used and are selected for or adapted to the individual. A **cast** is usually made from fibreglass casting tape or plaster of Paris; it is usually cylindrically applied and non-removable. However in certain instances casts may be bi-valved (cut in half) or made to be removable (Conine et al 1990). Both splints and casts can be serially adjusted to accommodate gains in range of movement. In addition, devices are available that are angle adjustable, which may also be useful in applying prolonged stretch. For clarity, the term 'orthoses' refers to all external devices, including splints and casts, but is commonly accepted in practice to mean devices provided by orthotists, usually for long-term management.

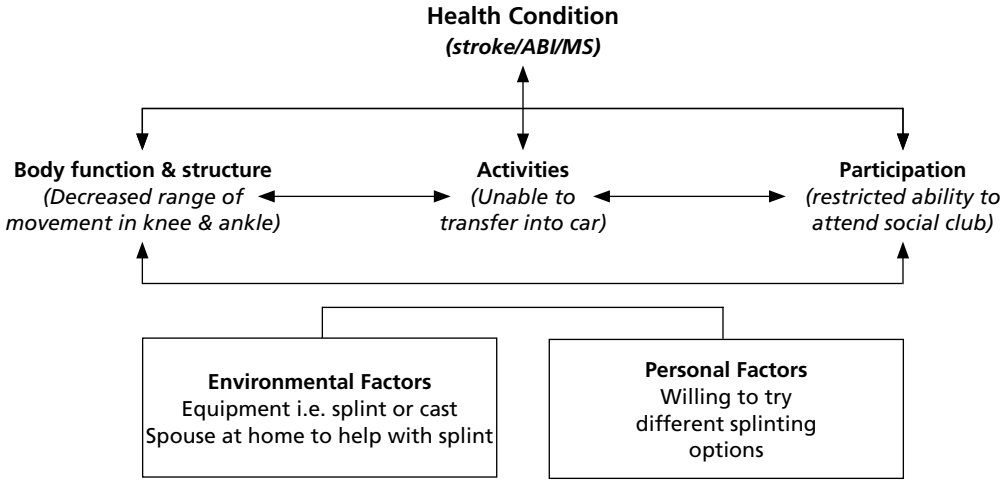

Figure 1.1 Illustrating the biopsychosocial nature of the splinting process within the ICF framework (WHO 2001)

The primary aim of splinting addressed in this guideline is to correct and prevent contractures as a basis for the improvement of function. Using the *International Classification of Functioning, Disability and Health* (ICF) (World Health Organization [WHO] 2001) as a theoretical framework, Figure 1.1 illustrates that although

physiotherapists and occupational therapists may work at a body structure and function level (e.g. pain, decreased range of movement in the knee and ankle), the primary aim is always to reduce activity limitations (e.g. unable to transfer into a car) and participation restrictions (e.g. restricted ability to attend a social club).

Activity (function) can be defined as 'active' or 'passive' and is used in this way in this document (Sheean et al 2010). **Active function** is performance of a functional task by active movement of the individual's affected limb, for example to walk or use a fork to eat. **Passive function** (also referred to as 'ease of care') is when a task such as cleaning the palm of the hand (hand hygiene) of the affected limb is carried out by the individual using their unaffected (or less affected) limb or by someone else i.e. a carer or a combination of the two.

Guidelines do not replace sound clinical reasoning and good clinical judgement. Although the focus of this guideline is on splinting interventions that target the maintenance or increasing range of joint movement, this aim must be situated in the wider context and the needs of the individual person. In line with evidence-based practice, therapists must justify their actions based not only on the published evidence but also on their clinical experience and patient preference (Sackett et al 1996). Context is also a key consideration, and splinting should not be undertaken in isolation; it is one part of a comprehensive goal-directed rehabilitation or management programme (Association of Chartered Physiotherapists in Neurology [ACPIN] 1998, ISWP 2012, NICE 2014, National Institute for Health and Care Excellence [NICE] 2013, Royal College of Physicians [RCP] 2009). Given that physiotherapists and occupational therapists have a shared overall aim of improving and preserving function in the management and treatment of contractures (Kilbride et al 2013), the decision to develop joint therapy guidance was taken.

1.1 Clinical context

There are an estimated eight million people with a neurological condition in the UK (Neurological Alliance 2003). Resultant impairments such as contractures and spasticity can be seen in neurological conditions, including stroke, MS and TBI (Fergusson et al 2007, van Kuijk et al 2007).

The incidence of contractures in people with neurological conditions in the UK is largely unknown. The global occurrence of contractures in neurological conditions in the published literature varies widely. For example, 11% to 84% of people with TBI develop contractures (Moseley et al 2008, Yarkony and Sahgal 1987) whereas in those with hemiplegia or severe stroke, the reported incidence ranges from 43% (Sackley et al 2008) to 100% (Malhotra et al 2011). Studies undertaken in Australia report that half of all adults admitted to hospital with stroke develop at least one contracture (Kwah et al 2012). In a cohort of 156 participants with MS, over half had a contracture in at least one major joint of the upper or lower limb; the most common site was the ankle (43.9%) (Hoang et al 2013).

Identification of clinical factors to predict who will develop contractures is complicated and complex as it is dependent upon the interaction of many factors (Diong et al 2012, Kwah et al 2012). The sequence of events in contracture formation is not known and is likely to vary between different diagnoses (Harvey et al 2011). The documented time course for contracture formation is wide; from within 2 weeks of stroke (Ada et al 2006) and appear to largely stabilise by 32 weeks (Pandyan et al 2003). In stroke, contracture is most frequently predicted by weakness (Kwah et al 2012, Pandyan et al 2003) and

reduced motor function (Kwah et al 2012, Malhotra et al 2011), and linked with increased stroke severity (Kwah et al 2012). It is not predicted by degree of spasticity or pain (Kwah et al 2012). While the presence of spasticity and contractures is not synonymous, and for some people spasticity positively helps function e.g. for transfers, for others their shared presence can play a role in the development of contractures (Ada et al 2006). The minimisation of the negative effects of secondary complications such as contractures remains a key aim of rehabilitation (Cumberland Consensus Working Group et al 2009).

Splinting is a common part of treatment and management in neurological practice (Coppard and Lohman 2008, Edwards and Charlton 2002), but the effectiveness of splinting as a stretch intervention for contractures remains the subject of ongoing debate (Katalinic et al 2010, Kilbride et al 2013, Lannin and Ada 2011). Discussions over the efficacy of splinting remain alongside the call for more research, but splinting continues to be used in clinical practice and therapists need direction in dealing with this area of clinical uncertainty (Adrienne and Manigandan 2011, Andringa et al 2013).

1.2 Context of service delivery

Adults with a neurological condition access health and social care in different stages of their recovery or condition and in different settings, including hyperacute stroke units, community rehabilitation teams, nursing or care homes and their own homes. As part of the overall agenda for improved management of long-term conditions (Department of Health [DH] 2005), splinting can play a part in enhancing or maintaining an individual's level of occupational performance – that is, engagement in activity and participation in society. Equally important is that therapists working across health and social care give due consideration to the social determinants of health as described in the Marmot Review (Marmot 2010). Although this report is based only on English data, the key message is relevant across the United Kingdom: access to and equity of health should not be determined by social factors such as wealth, employment or housing.

The financial burden of contracture prevention and management, where documented, is considerable. In the absence of more up-to-date figures, the treatment cost for one contracture was estimated at £10,000 where inpatient treatment and surgery were required (Wade 1992). The conservative prevention and management of contractures, where appropriate, is therefore advocated. Where a person is at risk of losing joint range, national guidance recommends that specific treatment modalities such as casts and splints be considered as an option (NICE 2013, NICE 2003, ISWP 2012). The cost of splinting varies depending on the type and design. A prefabricated positional splint may cost in the region of £90 plus VAT, but a custom-made device will be more expensive because of the cost of the time and the material to fabricate the device.

1.3 The occupational therapy and physiotherapy role

Occupational therapists and physiotherapists, as members of the wider health and social care team, play a key role in the management of long-term neurological conditions. As part of a comprehensive goal-directed rehabilitation or management programme, splinting can be a useful adjunct in the therapist's toolbox in the prevention and correction of contractures.

Both professions are committed to a person-centred and holistic philosophy. The core essence of the roles is described by their professional bodies as follows:

Occupational therapy is a unique philosophy that acknowledges the link between what people do and their health and wellbeing. To the profession 'occupation' means all the activities a person undertakes, enjoys and values. Occupational therapists are health and social care professionals who help people of all ages carry out activities they need or want to do, but as a result of physical or mental illness, disability or being socially excluded, are prevented from doing. (www.cot.co.uk)

Physiotherapy helps restore movement and function when someone is affected by injury, illness or disability. Physiotherapists help people affected by injury, illness or disability through movement and exercise, manual therapy, education and advice. At the core is the patient's involvement in their own care, through education, awareness, empowerment and participation in their treatment.
(www.csp.org.uk/your-health/what-physiotherapy)

The decision to develop joint therapy guidance reflects the shared goal to enhance function which is integral to both professions.

1.4 Practice requirement for the guideline

The practice requirement for this guideline is supported by a national online survey of members from the College of Occupational Therapists Specialist Section Neurological Practice (COTSS-Neurological Practice) and the Association of Chartered Physiotherapists in Neurology (ACPIN), a professional network of the Chartered Society of Physiotherapy (CSP) (Kilbride et al 2013). A total of 420 therapists completed the survey, of which the majority of responses indicated the need for practice guidelines. The previous guidelines in this clinical area were produced by ACPIN (1998) and have since been withdrawn from circulation.

Given the multifaceted nature of splinting as a complex intervention, many factors and questions remain about practice. For example, the review of the evidence shows that little is known about the dosage (wearing regime), with further variation across the upper and lower limbs, in addition to which muscles are involved (see evidence tables in Appendix 7). These practice guidelines aim to provide therapists with direction in dealing with clinical uncertainty (Adrienne and Manigandan 2011, Andringa et al 2013) and in identifying when **to** splint or cast and, equally importantly, when **not** to splint.

1.5 Topic identification process

Practice guidance for splinting in neurology, as a guideline topic, was jointly identified by members of COTSS-Neurological Practice and ACPIN. A decision was made to focus the guideline on the treatment and management of contractures in adults with neurological dysfunction as this was the most commonly cited reason for splinting by members of the professional networks (Kilbride et al 2013).

A joint proposal to produce an occupational therapy and physiotherapy practice guideline for splinting in neurology was developed by COTSS-Neurological Practice and ACPIN. The CSP Good Practice Panel and the College of Occuaptional Therapists' Practice Publications Group subsequently approved the proposal in January 2012.

1.6 Conflicts of interest

All Guideline Development Group (GDG) members (core group and co-opted), stakeholders and external peer reviewers were asked to declare any pecuniary or non-pecuniary conflicts of interest, in line with guideline development procedures (COT 2011a).

The following declarations were made:

- Six members of the GDG were members of either the COTSS-Neurological Practice or ACPIN professional networks.
- One member of the GDG was Stroke Forum Chair of COTSS-Neurological Practice at the time of the development of the joint proposal.
- Two members of the GDG teach postgraduate splinting courses.
- One member of the GDG was involved in the development of the ACPIN (1998) splinting guidelines.
- One member of the GDG was involved in a project evaluating focal spasticity intervention (physical and pharmacological) in the arm using botulinum toxin A and was a chief investigator for a National Institute for Health Research (NIHR) clinical lectureship award investigating focal spasticity intervention for leg spasticity (physical and pharmacological).
- All but one member of the GDG co-authored publications cited in the guideline.
- One member of the GDG is a member of the British Association of Prothetists and Orthotists.
- External peer reviewers and stakeholders identified their membership of professional organisations.

The nature of the involvement in all declarations made above was not determined as being a risk to the transparency or impartiality of the guideline development.

2 Objective of the guideline

The guideline objective is:

> ***To promote best practice in the use of splinting in adults with neurological dysfunction for the prevention and correction of contractures.***

It is intended that occupational therapists and physiotherapists use this practice guideline to inform their work with service users, with a particular focus on empowering the service user to be as fully engaged in the self-management of their long-term neurological condition. Furthermore, the guideline can be used as a resource with other end users, such as therapists and healthcare students.

The guideline should be used in conjunction with the current versions of the following professional practice requirements, of which knowledge and adherence is assumed:

- *Standards of conduct, performance and ethics* (Health and Care Professions Council [HCPC] 2012a).
- *Standards of proficiency – occupational therapists* (HCPC 2013).
- *Code of ethics and professional conduct* (COT 2010).
- *Professional standards for occupational therapy practice* (COT 2011b).
- *Standards of proficiency – physiotherapists* (HCPC 2012b).
- *Quality assurance standards for physiotherapy service delivery* (CSP 2013).
- *Code of members' professional values and behaviour* (CSP 2011).
- *Working for health equity* (University College London Institute of Health Equity 2013).

As guidance rarely produces definitive answers (Scalzitti 2001), it is intended that this guideline be used alongside the therapist's clinical expertise; as such, the clinician is ultimately responsible for the interpretation of the evidence-based recommendations in the context of their specific circumstances and the service user's individual needs and preferences.

To assist clinicians with their clinical reasoning, an exploration of the physiological background to the development of contracture has been included.

3 Examining the theoretical basis for splinting in contracture management

3.1 Introduction

This chapter critically examines the theory underpinning the potential use of splinting for contracture management in adults with neurological dysfunction. The assumed benefits of splinting for contracture management are based on the potential effects of long-term and continuous stretch on the non-neural (muscle–tendon unit; MTU[1]) and neural (such as spasticity as a positive feature of the upper motor neuron syndrome, (UMNS)) mechanisms involved in their development. The chapter is divided into these two areas, each section providing an overview of the key evidence.

3.2 Overview of non-neural mechanisms relevant to reduction in muscle extensibility

Studies draw upon animal models and evidence from studies involving human participants, which indicate the potential for increasing the number of sarcomeres in series in humans (Boakes et al 2007, Theis et al 2013). Although plastic changes in MTUs in response to long-term stretching (splinting) can happen in the absence of normal muscle innervation (Dupont Salter et al 2003, Williams and Goldspink 1976), most studies have involved healthy animals and humans, and generalisation of the results to different muscle and tendon in different pathological conditions with different aetiologies should be done with caution. Due to anatomical differences between the species (Heslinga et al 1995), and altered structural and material properties of the muscles (including connective tissues) and tendons in pathological conditions (Barber et al 2012, Boakes et al 2007, Mohagheghi et al 2007, Zhao et al 2009), it remains unclear whether a human MTU responds similarly to animal muscles.

Restriction in range of movement can lead to changes in soft tissue structures, such as shortening and increased stiffness within the MTU, the joint capsule and ligaments (Farmer and James 2001, Herbert and Balnave 1993, Herbert and Crosbie 1997, Lannin and Ada 2011). Overall MTU length can alter with changes in the length of the various constituent components, such as muscle, muscle fibres, sarcomeres and tendon. Although it is difficult to ascertain in the practice setting which component of the MTU has become shortened, it is important that therapists consider this factor to deepen their understanding of the clinical picture when considering whether lengthening via splinting can halt or reverse the adaptations.

In healthy animals and humans, the adaptation of muscles and tendons to length change is complex. Variations are seen across different muscle groups (Heslinga et al 1995, Spector et al 1982, Tabary et al 1972, Williams and Goldspink 1971), different species (Comes et al 2004, Coutinho et al 2004) and different ages. Changes can, likewise, be reversible (Crawford 1973, Urso et al 2006, Williams 1988, Williams and Goldspink 1978, Williams and Goldspink 1973, Williams and Goldspink 1971).

[1] A muscle and the tendon that connects it to the skeleton are collectively called a muscle–tendon unit (MTU). Muscle and tendon can be considered as separate components of the MTU.

3.2.1 Adaptation of MTU properties in shortened positions

MTUs maintained in a shortened position can show an overall decrease in length and increase in stiffness for a number of reasons:

- Decrease in the number of sarcomeres (Heslinga et al 1995, Spector et al 1982, Tabary et al 1972, Williams 1988, Williams and Goldspink 1978, Williams and Goldspink 1973).
- Decrease in the length of the sarcomeres (Spector et al 1982).
- Decrease in the length of the muscle fibres (Spector et al 1982, Tabary et al 1972, Williams and Goldspink 1971) due to the reduction in the number and/or length of sarcomeres.
- Decrease in the length of the tendons (Herbert and Balnave 1993, Herbert and Crosbie 1997).

These factors, along with an increase in accumulation of connective tissue (Jarvinen et al 2002, Williams 1988, Williams and Goldspink 1984, Williams and Goldspink 1973), can all contribute to greater stiffness within the muscle, with a subsequent increased resistance to movement. In addition, although tendon stiffness may also be reduced (Couppe et al 2012, de Boer et al 2007), the overall stiffness of the MTU may be increased and contribute to the development of contractures (Farmer and James 2001, Herbert and Balnave 1993, Herbert and Crosbie 1997, Lannin and Ada 2011).

Muscle atrophy (Goldspink 1977, Herbert and Crosbie 1997, Heslinga et al 1995, Spector et al 1982) and a shift in the length–tension relationship of the MTU (Crawford 1973, Tabary et al 1972, Williams and Goldspink 1978) may also be observed in MTUs maintained in shortened positions. This means maximum muscle tension is less, and is produced at shorter lengths, with a longer electromechanical[2] delay due to changes in tendon compliance (increased compliance due to a weaker tendon), and is transferred to the skeleton with less efficiency (Couppe et al 2012, de Boer et al 2007, Narici and Maganaris 2006, Reeves et al 2003), thus further compromising the performance of the MTU.

3.2.2 Adaptation of MTU properties to lengthened positions

Maintenance of MTUs at longer lengths, for example with splinting, may result in:

- An increase in the number of in-series sarcomeres (Boakes et al 2007, Heslinga et al 1995, Spector et al 1982, Tabary et al 1972, Williams 1988, Williams and Goldspink 1978, Williams and Goldspink 1973).
- An increase in the length of the muscle fibre (Boakes et al 2007, Spector et al 1982, Williams and Goldspink 1971).
- An increase in the length of the tendon (Crawford 1973, Williams 1988).
- Preservation of the normal length–tension relationship and MTU stiffness (Tabary et al 1972, Williams and Goldspink 1978).
- Prevention of accumulation of connective tissue within the muscle (Williams 1988, Williams and Goldspink 1984, Williams and Goldspink 1973).
- Increased stiffness of the MTU, but with reduction of muscle atrophy (Goldspink 1977, Herbert and Balnave 1993, Spector et al 1982).

[2] Electromechanical delay refers to the time interval between the start of muscle activity and initiation of movement. Its duration is affected partially by the time required for stretching series elastic components.

3.2.3 Clinical application

Decreased range of movement of the ankle in people with stroke has been associated with reduced gastrocnemius fascicle length and higher fascicular and muscle stiffness (Gao et al 2009). This is suggestive of a relationship between altered muscle architecture and muscle properties and the clinical symptoms of muscle stiffness and contracture. While this correlation cannot infer a cause and effect phenomenon, an increase in fascicular length with increased muscle length might be expected following an increase in the overall range of movement of the ankle (along with the potential for improvement in passive or active function).

Serial casting as an intervention to provide long-term stretch might increase the overall range of movement, but an increase in fascicle and muscle length from serial casting has not been reported. This could be explained partly by an increased compliance of the tendon (reduced Young's modulus,[3] i.e. weaker tendon) after stroke or immobilisation (Zhao et al 2009), where a tendon may stretch relatively more than the muscle element of the MTU during movement and hinder the potential benefits of stretching on the muscle component.

In children with spastic diplegic cerebral palsy, Theis and colleagues (2013) reported an increase in the medial gastrocnemius muscle, fascicles and tendon lengths with short-duration stretching in one treatment session. Although the limitations of extrapolating these results to an adult population with a different neurological dysfunction are acknowledged, this study provides the first *in vivo* evidence for the potential effectiveness of long-term stretching and/or splinting for inducing plastic changes in the muscle and tendon components of the MTU in this population.

The adaptations in MTUs in response to prolonged stretch described in this section in theory may assist in improving overall MTU extensibility, thereby reducing the non-neural component of contracture formation. MTU stiffness, however, is relative to both the intrinsic mechanical properties and the neural mechanisms that control activation (Guissard and Duchateau 2006, Guissard and Duchateau 2004, McHugh et al 1992).

3.3 Overview of neural mechanisms relevant to reduction in muscle extensibility

People with neurological dysfunction, including those with positive signs of UMNS, may show increased resistance to elongation of the MTU. This has been attributed in part to the previously described alterations in the intrinsic properties of the MTU (Galiana et al 2005, Li et al 2006, Mirbagheri et al 2008) and to an increased gain in, or reduced threshold of, the stretch reflex[4] (Calota et al 2008).

3.3.1 Spasticity and contractures: reflex mechanisms

The presence of spasticity as part of UMNS does not equate with contractures, but it can interfere with range of movement, thus putting the person at risk of contracture. Spasticity has been identified as making a significant contribution to the increased resistance felt during passive stretching (Li et al 2006). An increase in stretch reflex gain, which is associated with increased activation in spastic muscles, can be attributed to a number of complex factors at the spinal level, including the following:

[3] Young's modulus represents the material properties of a tissue. It is defined as the change in the tissue stress for a given change in its strain. A tendon with a lower Young's modulus will be more compliant and will elongate more with respect to its original length for a given tensile force applied to its unit cross-sectional area.

[4] Increased gain here refers to both increased sensitivity and response to stretch.

- An increase in motor neuron pool excitability (Priori et al 2006).
- The inappropriate recruitment of motor neurons (Mirbagheri et al 2008).
- An increase in muscle spindle activity (Gracies 2005, Li et al 2006).
- Reduced presynaptic inhibition (Priori et al 2006).

Factors such as these can lead to a reduced threshold of the tonic stretch activity in spastic muscles – that is, the stretch reflex is triggered in response to low stretching velocities at lengths that do not result in reflex activity in relaxed healthy muscles (Calota et al 2008, Pisano et al 2000).

Therefore, a theoretical construct for splinting in the presence of spasticity is based on the potential efficacy of prolonged stretching of the MTU in modifying pre- and postsynaptic mechanisms that affect the stretch reflex. In practice, interventions such as splinting, if delivered as part of an overall goal-directed rehabilitation or management programme, may be helpful in downregulating the stretch reflex (for example, alter the reflex gain). This may help to improve active functional performance of activities or increase the ease of care or self-care through the maintenance or improvement of range of movement (passive function).

3.3.2 Exploring the potential modifying effects of stretch on reflex mechanisms via splinting

Drawing upon animal and human models, there is theoretical and empirical evidence to support the potential use of stretch (e.g. splinting) as a way to modify neural mechanisms contributing to increased resistance to stretch.

Williams (1980) used an animal model and immobilised rat-tail muscles in either a shortened or lengthened position for four days. Results showed that muscle spindles in muscles immobilised in a shortened position became active in response to stretch at shorter lengths compared with spindles in muscles immobilised at longer lengths, which became active at extreme muscle lengths. Moreover, spindles in the muscles immobilised in the shortened position had a heightened response to the rate of stretch, but those immobilised at long lengths had significantly lowered acceleration sensitivity. Williams (1980) concluded that changes in the mechanics of the intrafusal muscle fibres and the sensitivity of the receptors in the muscle spindles were responsible for the findings – that is, normal adaptation of a muscle spindle. Gracies (2005) argued that the same mechanisms might be involved in the increased sensitivity of spastic muscles to stretch in the human model. In other words, increased muscle spindle activity could help to explain abnormal velocity- and length-dependent resistance of the MTU to stretch in spastic muscles. In spastic muscles, an overall increase in the stiffness of the MTU (e.g. associated with increased amount of connective tissue and reduced number of sarcomeres in the muscle held in a shortened position) could result in muscle spindles experiencing more of the stretching force. Splinting (stretching) may therefore have the potential to interfere with these mechanisms, addressing the non-neural components described previously, which in turn will have an effect on the neural mechanism, which can help to modify alteration in neural activation, such as spasticity.

It has been demonstrated in healthy individuals that passive static stretching (10 minutes of stretching a day for 30 days over 6 weeks) of the MTU can reduce the Hoffman (H) reflex[5] and tendon reflexes (Guissard and Duchateau 2004); this has been

[5] The H reflex is a spinal reflex used to give an indication of the overall excitability of the motor neurons. A smaller H reflex may indicate less sensitivity to stretch.

associated with increased presynaptic inhibition of sensory signals (Guissard et al 2001) and thus reduced sensitivity to stretch. However, different pre- and postsynaptic spinal mechanisms might be involved in the inhibition of reflexes (reduction of the motor neuron excitability or excitation) at different magnitudes of stretch. For example, presynaptic inhibition might be involved in reducing motor neuron excitation or excitability at small magnitudes of stretching (e.g. ankle dorsiflexion of 10 degrees), but Golgi tendon organs 1b afferents, Renshaw recurrent loops[6] and alteration in supraspinal interneuronal circuitry were proposed by Guissard et al (2001) as possible mechanisms involved with stretches of large magnitude (e.g. ankle dorsiflexion of 20 degrees or more). In healthy individuals, repetitive and prolonged passive stretching (dorsiflexing the ankle to 10 degrees repeatedly at 1.5 Hz for 1 hour) could reduce large 1a afferent sensitivity and consequently the reflex sensitivity to stretch (Avela et al 1999, Guissard et al 1988).

Other mechanisms proposed for alteration of neural activation might also be affected via stretching (splinting). In both healthy individuals and people with hemiplegia, continuous or intermittent pressure on the Achilles tendon applied via a transducer pressing the tendon resulted in a reduction in the size of the H reflex (Kukulka et al 1986, Leone and Kukulka 1988). Watkins (1999) claimed that pressing the Achilles tendon could be similar to the activation of the Golgi tendon organs in a spastic muscle undergoing prolonged slow stretching. A drop in the H reflex may be inferred from similar mechanisms during splinting. Mirbagheri and colleagues (2008) showed that stretch reflex gain and the intrinsic MTU stiffness was dependent on position in people with and without spasticity, and reflex gain decreased but intrinsic stiffness increased at longer lengths. Reduction in the reflex gain at positions of extreme dorsiflexion was suggested to be related to the activation of group III/IV afferents,[7] which are preferentially activated at extreme muscle lengths (Mirbagheri et al 2008).

In all the studies reviewed, reduction in the motor neuron excitation or excitability in response to stretching of varied duration was short lived. It should be noted that spasticity in different UMNS might be of a different nature (Faist et al 1999, Tsao and Mirbagheri 2007) due to the cause and location of the lesion, and hence observed responses to prolonged stretching might be different for different pathologies. Furthermore, methodological inconsistencies in the use of stretching in healthy and patient populations are noted, along with a wide variation in the dosage of stretch and how it was applied.

3.4 Summary of potential effect of splinting on non-neural and neural mechanisms in the prevention and correction of contracture

The current literature offers a complex and at times conflicting picture about how different muscles and tendons potentially adapt to (sustained) stretch. In particular, the inconsistency in the working definitions of the stretch magnitude applied (i.e. length of the MTU at which stretch is applied plus the duration and frequency of stretch) is not consistent across studies, and no clear interpretation can be made based on the results.

Although the literature can, in part, provide theoretical evidence for the potential effects of splinting on the non-neural and neural mechanisms involved in the prevention and correction of contractures, the results of the different studies are

[6] Renshaw cells are inhibitory interneurons in the spinal cord.
[7] Group III/IV afferents are unmyelinated or small-diameter myelinated fibres including nociceptors and thermoreceptors.

inconsistent and short lived. With so much still unknown, there is a real need for high-quality research to explore in depth the 'who?' (age, pathology), the 'what?' (response to stretch across different muscles or tendons) and the 'how?' (dosage, intensity, joint position) of splinting for contracture management. Such studies need to address these questions within the clinical practice setting as one part of a comprehensive goal-directed rehabilitation or management programme where the aim is to use gains or maintenance of range in movement for passive or active function (ACPIN 1998, RCP 2009).

4 Guideline scope

4.1 Clinical question

The key question covered by this guideline is:

> ***What is the evidence for the use of splinting in adults with neurological dysfunction for the prevention and correction of contractures?***

Implicit within this question is the recognition that service users are concerned particularly with functional outcomes, active or passive, and wider participation in society. To achieve these aims within a framework of a biopsychosocial model of disability (WHO 2001), changes and maintenance in body structures and functions are required, and as such, these are addressed in this guideline.

4.2 Target population

This practice guideline relates to adults aged 18 years and over, who have or are at risk of contracture from neurological dysfunction and require splinting as one part of a comprehensive goal-directed neurological rehabilitation or management programme. This guideline draws upon the literature from the fields of stroke, ABI and MS, but it is envisaged that the guidelines will have broader applicability across other neurological conditions.

There are no restrictions or limitations on gender, ethnicity or cultural background.

There are no exclusions for comorbidities, but each service user should be assessed individually (taking into account relevant comorbidities) when determining appropriate care or action in relation to guidelines and recommendations. Please see Section 8 for further guidance on when caution may be required when considering splinting.

4.3 Target audience

This practice guideline will largely be relevant to occupational therapists and physiotherapists working in the field of adult neurology across the full spectrum of health and social care settings, from hyper-acute stroke units in acute hospital trusts to nursing or care homes in the community and people's own homes. This guideline has been developed to assist occupational therapists and physiotherapists with clinical decision-making when considering the process of splinting for contracture in adults with a neurological condition. It does not provide practical information on how to undertake splinting.

In addition to occupational therapists and physiotherapists, it is suggested that this practice guideline may also be relevant for:

- Other members of the multidisciplinary team, such as orthotists, rehabilitation medicine physicians and nurses.
- Service users.

- Managers responsible for purchasing splinting equipment.
- Pre- and postgraduate university tutors.
- Commissioners and service providers.
- Charitable organisations (e.g. Stroke Association, Headway, Multiple Sclerosis Trust, Multiple Sclerosis Society).
- Student therapists.
- Researchers.
- Health and social care settings (except schools).

It is intended that this practice guideline provides a comprehensive practical resource for occupational therapists, physiotherapists and the multidisciplinary team working with adults with a neurological health condition who have or are at risk of developing contractures.

As splinting is largely a postgraduate clinical skill, all therapists must ensure they work within their scope of practice and, where appropriate, seek supervision from more senior staff. Practical splinting training should be undertaken as necessary.

5 Guideline development process

Detailed information on the following steps within the guideline development process can be found in the *Practice guidelines development manual* (COT 2011a).

5.1 Guideline Development Group

Membership of the core GDG (see Appendix 1 for full list) consisted of two occupational therapists and three physiotherapists with extensive experience in adult neurology and expertise in splinting. It was determined that, given the specific therapy nature of the practice guideline, the core group would be profession specific, with any expertise required from other stakeholders and service users most effectively obtained outside core group meetings via a reference group and consultation.

This was a funded project (see Section 5.5), but much of the guideline development work was undertaken in private time, with additional support from external agencies such as the professional bodies and employers allowing members time to attend meetings. The GDG co-opted the following people for specific activities:

- Professor Lorraine DeSouza to provide professorial research and editorial advice.
- Dr Amir Moghagheghi to undertake a specialist literature review on the pathophysiology of contracture.
- Fabienne Malaprade to undertake semistructured interviews with service users to gain insight on the experience of using splints.
- Dr Jim Ashworth-Beaumont to provide specialist advice on orthoses.

5.2 End user and stakeholder involvement

5.2.1 End user involvement

As the key end users, therapists have been involved in all stages of the guideline development process. First, a national survey of 420 neurological occupational therapists and physiotherapists was undertaken as part of the initial scoping exercise (Kilbride et al 2013). The main items identified in the survey as important to therapists were clinical reasoning, evidence-based guidelines, and wearing times and regimes. Next, an overview of the proposed scope of the guidelines was presented at both the ACPIN and COTSS-Neurological Practice national conferences to provide further opportunity for comments from end users. Feedback was reviewed and, where indicated, incorporated into the final scope document, which was then submitted to the College of Occupational Therapists' Practice Publications Group and the CSP Good Practice Panel for approval. Over 200 therapists from across the UK were then involved in the development of the guidelines by taking part in three rounds of a formal Delphi consensus process (see Section 8 and Appendix 3 for further detail).

5.2.2 Stakeholder involvement

In addition to members of ACPIN and COTSS-Neurological Practice, other key stakeholders with a potential interest in the guideline were identified by the core group membership at an early guideline meeting. Specific attention was given to identifying

national charity and voluntary organisations that may represent service users and professional colleagues who may work as part of the multidisciplinary team, including:

- Stroke Association.
- MS Society.
- Therapists in MS.
- Headway.
- Different Strokes.
- British Association of Prosthetists and Orthotists.

These stakeholders recognised that therapists were the primary end users of the guideline, and there was broad support for the development of the guideline. A targeted approach was used to seek views on the full draft guideline from professional bodies, national charities and clinical experts. All comments were considered for inclusion within the final guideline document.

5.3 Service user involvement

The GDG identified that obtaining service users' perspectives on splinting for the management and treatment of contractures was fundamental to the project. There is a paucity of research into user experience on splinting (Andringa et al 2013, Kuipers et al 2009). Studies conducted in the Netherlands (Andringa et al 2013) and the USA (Beaty and Murphy 2013) explored users' experience in stroke and concluded that more qualitative in-depth exploration was required.

Informal feedback from service users during the scoping phase indicated support for the guideline. To this end, and following ethical approval by the School of Health Sciences and Social Care Research Committee Brunel University London (reference number 13/10/STF/03), ten participants were recruited through local support and charitable organisations to take part in the interviews: three men and three women with stroke, two men and one woman with ABI, and one man with MS. Following consent, two carers were also involved in the interviews at the request of the respective participants. This qualitative evidence was used to provide contextual support in Section 8.3. Appendix 4 contains more details on the service user involvement process.

Service users and carers who participated in the interviews were invited to review the final guidelines.

5.4 External peer review and consultation

The GDG identified three independent peer reviewers to review a draft of the full guideline document. Reviewers were selected for their clinical expertise in the field, and/or their guideline development experience or knowledge. A one-month consultation period was established to enable members of COTSS-Neurological Practice and ACPIN (guideline end users) and stakeholders to comment on a draft of the full guideline.

The GDG considered the feedback received from all stakeholders, service users, peer reviewers and end users when forming the final recommendations and guideline document.

5.5 Declaration of funding for guideline development

The practice guideline, *Splinting for the prevention and correction of contractures in adults with neurological dysfunction: practice guideline for occupational therapists and physiotherapists*, has been developed by a group led by COTSS-Neurological Practice and ACPIN. Specialist sections and professional networks such as COTSS-Neurological Practice and ACPIN are official branches of the College of Occupational Therapists and the Chartered Society of Physiotherapy with specialist or regional interests, which, through their membership, are able to engage expert practitioners, educators and researchers in the development of guidelines and access the required clinical and research expertise. As a membership organisation, the major source of funding for the College of Occupational Therapists and its specialist sections and the CSP and its professional networks is obtained from membership. Other sources of income are primarily from advertising and events.

Joint funding was received from COTSS-Neurological Practice and ACPIN, and contracts of work to be undertaken were drawn up with Brunel University London, which enabled the academic team members to undertake work such as the specialist literature review, the critical appraisal of the literature and the Delphi survey. There were no external sources of funding.

5.6 Guideline appraisal and ratification process

The guideline proposal, scope and final document were all reviewed and subsequently ratified by the College of Occupational Therapists' Practice Publications Group and the CSP's Good Practice Panel, in line with the requirements of the *Practice guidelines development manual* (COT 2011a).

The final version of this guideline was approved by the College of Occupational Therapists' Practice Publications Group and the CSP's Good Practice Panel in August 2014.

6 Guideline methodology

6.1 Guideline question

What is the evidence for the use of splinting in adults with neurological dysfunction for the prevention and correction of contractures?

The **PICO** participant/population/problem, intervention, comparison and outcome (PICO) framework (Table 6.1) was used to assist in developing the specific practice question further. This approach clarifies the specific care group or condition and the nature of the intervention to be investigated. A comparative treatment can be defined where applicable, together with the anticipated outcomes (the desired/undesired or expected results of the intervention). This level of specificity is important in developing the question so that it addresses the requirements of the scope (COT 2011a).

Table 6.1 PICO framework

Patient (service user), **P**opulation or **P**roblem/circumstance	Adults aged 18 years and over who have, or are at risk of, contracture as a consequence of stroke, ABI or MS
Intervention under investigation or action	Splinting for the prevention or correction of contractures
Comparison, which is an alternative intervention or action	Usual therapy practice (which may include no intervention)
Outcome desired	Range of movement as a specific outcome of this intervention, as one component of achieving functional activity and participation goals

6.2 Literature search methodology

A member of the GDG carried out the literature searches in conjunction with librarian information specialists from the College of Occupational Therapists and the CSP using a search strategy defined following discussion and agreement among the GDG.

The clinical and academic experience of the GDG meant there was prior knowledge that the therapy-specific evidence related to splinting was likely to be limited. An initial scope of the literature and review of a Cochrane review (Katalinic et al 2011) indicated a limited number of randomised controlled trials (RCTs) of the interventions; this is not unusual in rehabilitation research. Consequently, the review was not confined to RCTs, and all study designs that included the evaluation of splinting as a stretch intervention were included. Restricting the design to RCTs may have led to the exclusion of studies of interest and relevance to practice. On the basis of this, the initial aim of the search was wide to ensure there was adequate sensitivity to include all publications of relevance to adults with neurological impairment. Following initial scoping, however, evidence and publications were available for inclusion only within the diagnostic groups of stroke, ABI and MS. The focus for the evidence review was therefore limited to these three groups.

6.2.1 Key terms and inclusion/exclusion criteria

The strategy involved combining groups of key words. Four key categories or concepts and their related terms were identified: splints/casts/orthotics, physiotherapy, occupational therapy and neurology (stroke, MS, head/brain injury) (see Appendix 5). Terms were adapted to the specific requirements of each database. There were no language restrictions and no time limits; databases were searched from inception of databases to April 2013. Reference lists included in full-text papers were searched by hand for additional relevant texts.

Inclusion and exclusion criteria of papers

Inclusion:

- Adult (18 years and over).
- Diagnosis of stroke, MS or brain/head injury.
- Splinting (splints and casts) for contracture management (prevention or correction) is primary focus of intervention.
- Primary outcome: range of movement.

Exclusion:

- Case studies.
- Papers with less than 50% adults or target health conditions.
- Splinting for primary aim of promoting exercise.

Databases

The databases searched reflected the most likely sources of evidence for physiotherapy and occupational therapy and splinting for contracture management. Seven core databases were searched separately from their commencement period to the search date, as detailed in Table 6.2. The literature searches were carried out on 7 and 19 February 2012 at the CSP and the College of Occupational Therapists, respectively. The searches were re-run on 23 April 2013.

Table 6.2 Database searches

Core database	Period of search
CINAHL	1981 to 23.04.13
Medline	1966 to 23.04.13
Allied and Complementary Medicine (AMED)	1985 to 23.04.13
Physiotherapy Evidence Database (PEDro)	1929 to 23.04.13
PsycINFO	1872 to 23.04.13
Social Policy and Practice	1980 to 23.04.13
Health Management Information Consortium (HMIC)	1979 to 23.04.13

The following specialist databases were also searched: the College of Occupational Therapists specialist library catalogue; the CSP Online library catalogue (07.02.12; 23.04.13); OTDBASE (19.02.12; 23.04.13); OT Search (19.02.12; 23.04.13); OTSeeker

(19.02.12; 23.04.13); National Institute for Health and Care Excellence (14.02.12; 23.04.13); Cochrane Library (14.02.12; 23.04.13); NHS Evidence (14.02.12; 23.04.13); Database of Research in Stroke (DORIS) (14.02.12; 23.04.13); Hooked on Evidence (14.02.12; 23.04.13); and Google Scholar (14.02.12; 23.04.13).

In the majority of cases, the title, subject heading and abstracts were searched. Where the search term combinations were more general, some limitations were applied to provide a stronger focus on relevance. Examples of specific searches are given in Appendix 5.

6.3 Search results

The search findings identified a total of 1,076 papers. These were scrutinised for duplicates by the GDG project lead within database searches and cross-database search returns. As a result, 532 papers were excluded. The remaining 544 papers were screened by two members of the project group against an eligibility checklist that had been discussed and agreed previously with the wider GDG.

All members of the GDG have been involved in practice and research in this clinical area. Publications by all but one member of the GDG are included in this document. These publications are on related areas that are not central to the systematic review of practice evidence. Bias has been specifically avoided by the review of the document and selection of evidence by all members of the GDG.

Following screening, 479 papers that did not meet the inclusion criteria were excluded, leaving 65 papers for full review and critical appraisal. A search update a year later identified an additional 18 papers, of which 11 were included. A total of 76 articles were included in the final critical appraisal. A further 43 papers were excluded, and 33 papers were then used in the development of evidence statements.

An overview of the literature search outcomes is shown in Figure 6.1. The evidence tables for the included studies are in Appendix 7(a).

6.4 Strengths and limitations of body of evidence

Two members of the GDG independently reviewed the 76 articles identified as potential evidence. In the event of any discrepancy in grading, a third reviewer would be called upon, but this was not required. None of the articles identified was authored or co-authored by the two critical appraisers.

The quality of the evidence was initially assessed using the McMaster University evidence appraisal framework (Law et al 1998). Assessment took into account factors such as the appropriateness of the study design and the recruitment strategy; procedural rigour in data collection and analysis; confounding factors and potential biases; transferability; precision of results; and the value of the findings.

A grade was assigned to the evidence within an individual article using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach, as defined within the *Practice guidelines development manual* (COT 2011a). The grading reflects the research design and the confidence in the research findings.

The initial grading was allocated as follows:

- Randomised trial/systematic review = High.
- Observational study = Low.
- Any other evidence = Very Low.

Limitations in the design of a study or its implementation may, however, bias the estimates of the treatment effect. If there were serious limitations, then the downgrading of the quality of the evidence was considered, using the criteria shown in Table 6.3.

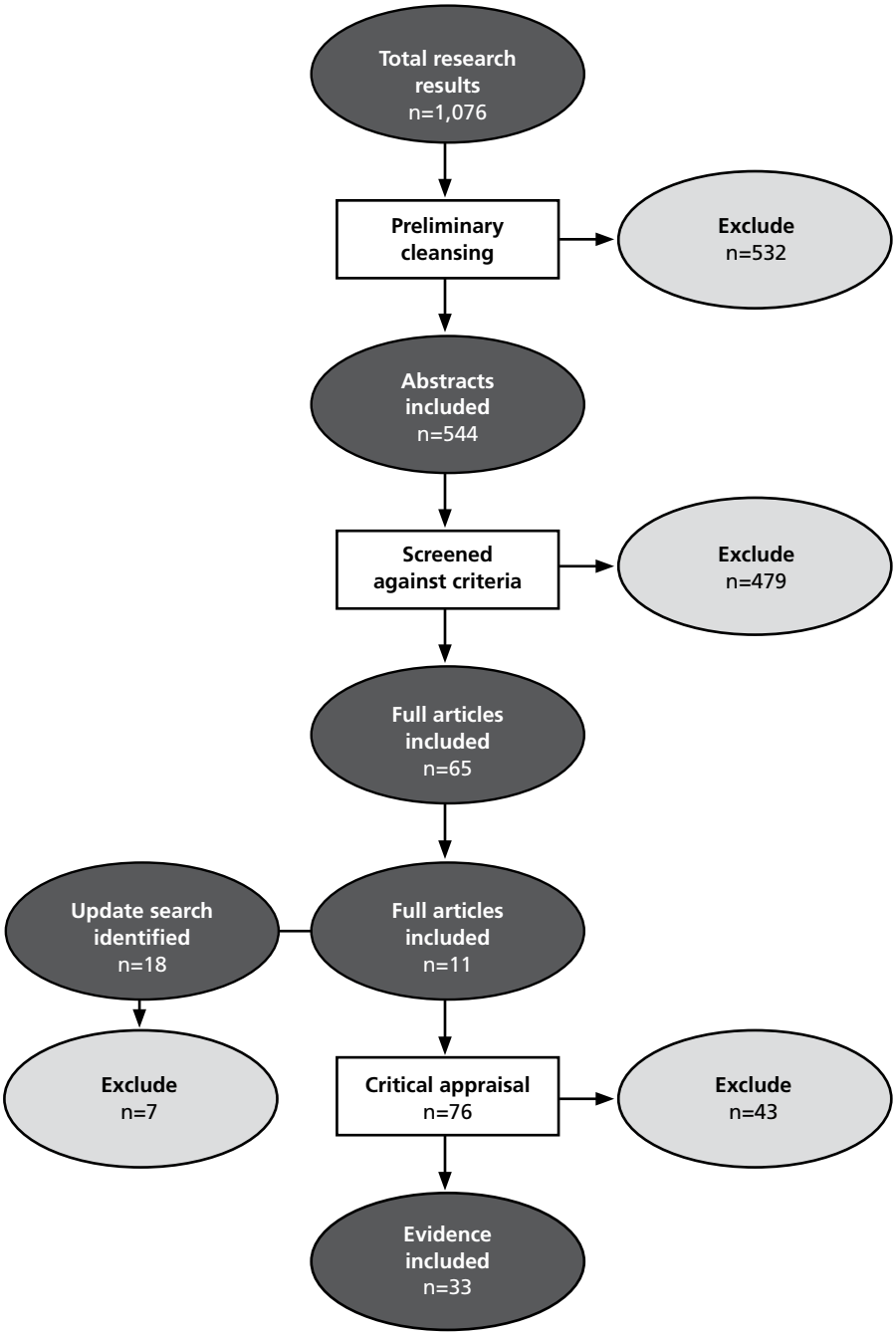

Figure 6.1 Literature search results

Table 6.3 Grading evidence up or down (after GRADE Working Group 2004)

Decrease* grade if *Each quality criterion can reduce the quality by one or, if very serious, two levels.	• Serious or very serious limitation to study quality • Important inconsistencies in results • Some or major uncertainty about directness of the evidence • Imprecise or sparse data (relatively few participants and/or events) • High probability of reporting bias
Increase grade if	• Magnitude of the treatment effect is very large and consistent • Evidence of a large dose-response relation • All plausible confounders/biases would have decreased the magnitude of an apparent treatment effect *Only studies with no major threats to validity should be upgraded*

Table 6.4 GRADE quality of evidence grading (after GRADE Working Group 2004)

Quality of evidence	Grading	Characteristics	Confidence
High	A	Based on consistent results from well-performed randomised controlled trials, or overwhelming evidence of an alternative source, e.g. well-executed observational studies with strong effects.	True effect lies close to that of the estimate of the effect. Further research very unlikely to change confidence in the estimate of the effect.
Moderate	B	Based on randomised controlled trials where there are serious flaws in conduct, inconsistency, indirectness, imprecise estimates, reporting bias or some other combination of these limitations, or from other study designs with special strengths.	True effect likely to be close to the estimate of the effect, but there could be a substantial difference. Further research is likely to have an important impact on confidence in the estimate of the effect and may change the estimate.
Low	C	Based on observational evidence, or from controlled trials with several very serious limitations.	True effect may be substantially different from the estimate of the effect. Further research is very likely to have an important impact on confidence in the estimate of the effect and is likely to change the estimate.
Very low	D	Based on case studies or expert opinion.	Any estimate of effect is very uncertain and may be far from the true effect.

A decision to increase or decrease the initial grade of the evidence was justified in the evidence table. The 'moderate' category came into play if there was a suggested change in the grading. Evidence was ultimately graded in one of four categories, as detailed in Table 6.4. If there was no reason to upgrade or downgrade the evidence, then the original grading remained.

Once the methodological quality of each piece of evidence was assessed, details for each item of evidence was collated into an evidence-based review table (see Appendix 7a).

6.5 Methods used to arrive at guideline recommendations

All GDG members reviewed the evidence tables generated from the literature review. The primary research question (see Section 4.1) was used to identify themes and interventions that were relevant in answering the question. All GDG members contributed their expert views to the discussion to develop recommendation options.

Where a number of papers supported an outcome and subsequent recommendation, an overall quality of evidence rating was identified:

- Where the evidence outcomes pointed in different directions towards both benefit and harm, the lowest quality of evidence determined the overall quality grade of the recommendation.
- Where the evidence outcomes pointed in the same direction towards either benefit or harm, the highest quality of evidence determined the overall quality grade of the recommendation.
- Where the balance of benefits and downsides was uncertain, the lowest grade of quality of evidence was assigned.

Strength of recommendation was the second element of the GRADE system applied using the categories 'strong' or 'conditional' to reflect the strength (Table 6.5).

Table 6.5 Strength of grade (after Guyatt et al 2008)

Strength	Grade	Benefits and risks	Implications
Strong	1. 'It is recommended . . .'	Benefits appear to outweigh the risks (or vice versa) for the majority of the target group.	Most service users would want or **should** receive this course of intervention or action.
Conditional	2. 'It is suggested . . .'	Risks and benefits are more closely balanced, or there is uncertainty in likely service user values and preferences.	The majority of service users would want this intervention, but not all, and therefore they should be supported to arrive at a decision for intervention consistent with the benefits and their values and preferences.

The development of the recommendations, including assignment of the overall quality and strength grading, was a consensus opinion obtained at a GDG meeting. There were no recommendations that were not agreed by all members of the group. A total of 33 papers were used to develop the recommendations (see Appendix 7a).

A recommendation decision form was completed for each recommendation developed, recording key information about the evidence used to form the basis of that recommendation, the overall allocation of quality of evidence, and strength of recommendation. The recommendation decision form facilitated discussion and recording of any specific or associated risks and benefits, and this was also highlighted in the final strength of recommendation. Any judgement by the GDG was documented as part of this decision-making process.

6.6 Limitations and any potential bias of guideline

Evidence included in the development of the guideline recommendations was sourced from published peer-reviewed journal articles. Relevant policy documents have been referenced within the contextual information, where applicable. It is acknowledged that any potential key 'grey literature' was not included.

The literature search identified a range of primary research in relation to the occupational therapy and physiotherapy studies involving splinting interventions for the management and treatment of contracture.

The review of the literature identified 33 items of evidence from which recommendations could be developed. The 33 studies were from a variety of countries. Australia (10) and the USA (8) had the most studies, followed by Italy (3), Iran (3), Germany (2), Turkey (2), Canada (1), Egypt (1), Korea (1), Switzerland (1) and the UK (1). The absence of research in MS and contracture management is noted as a limitation (see Section 10), and the recommendations are developed from population-based studies on stroke and ABI.

The majority of this evidence was assessed as low grade (grade C), followed by moderate-level evidence (grade B), very low-level evidence (grade D) and a small number of high-level studies (grade A):

- Grade A = 12% (n=4)
- Grade B = 28% (n=9)
- Grade C = 36% (n=12)
- Grade D = 24% (n=8)

Study designs were varied and included RCTs, controlled studies, crossover trials, case series and cohort designs. The evidence provided a number of higher-quality studies from a design and methodological perspective. The GDG downgraded over half (n=19, 58%) of the studies (grade A and C studies) due to concerns over the confidence of the estimate of the effects of the research. These decisions are noted in the evidence tables in Appendix 7a.

In addition, eight systematic reviews were identified in the search and critically appraised as part of the overall assessment of the literature (see Appendix 7b). These eight reviews were not used directly in formulating the splinting recommendations, as all individual papers had already been reviewed as part of this guideline development

process. Instead, to help improve rigour and reduce bias, the overall findings from the eight systematic reviews were compared with the splinting guideline recommendations at the end of the review process.

A limitation of this guideline is that in a number of cases, a recommendation has been developed on the basis of evidence, sometimes a single study and often of a low grade. Future emerging evidence will be reviewed to determine any impact it may have on the nature of the recommendations within this practice guideline.

The potential for bias in development and authoring was minimised through the rigorous nature of the guideline development. This was achieved through the systematic methodology adopted, the contributions of stakeholders and service users, and the valued opinions of the independent peer reviewers and occupational therapy and physiotherapy end users.

The College of Occupational Therapists, COTSS-Neurological Practice, the Chartered Society of Physiotherapy and ACPIN are fully acknowledged for their involvement in the funding and development of this practice guideline.

7 Guideline recommendations

These guideline recommendations refer to the application of stretch by splinting for the prevention or correction of contracture in adults with a neurological condition. As splinting is largely a postgraduate clinical skill, all therapists must ensure they work within their scope of practice, seek supervision from more senior staff where appropriate, and undertake practical skills training as required. Please also refer to Section 8 for further considerations for practice, including specific precautions for splinting.

Splinting is one part of a comprehensive goal-directed rehabilitation or management programme undertaken by occupational therapists and physiotherapists. As such, alternative treatment and management options are not explicitly reviewed or discussed. Some adjunctive interventions related to splinting were, however, necessarily considered during the process of reviewing the evidence.

It is important to remember that improvement in range of movement does not lead directly to functional (active or passive) gains. Where restricted range of movement is a limiting factor for function, however, meaningful change for a person may be achieved following an increase in range of movement.

The recommendations are organised in sections related to interventions for the arm and leg. These sections are separated into different areas by joint.

In accordance with the GRADE process (the **G**rading of **R**ecommendations **A**ssessment, **D**evelopment and **E**valuation, Grade Working Group, 2004), ***recommendations are scored according to strength, 1 (strong) or 2 (conditional), and graded from A (high) to D (very low) to indicate the quality of the evidence*** (Sections 6.4 and 6.5). Each statement starts with either 'It is recommended' or 'It is suggested'.

It is recommended . . . means most service users may want, or should receive, this course of intervention or action.

It is suggested . . . means the majority of, but not all, service users may want this intervention, and they should be supported to arrive at a decision for intervention consistent with the benefits and their values and preferences.

Additional details on individual studies (e.g. on recruitment numbers and statistical significant p values, effect sizes) can be accessed in the evidence-based review tables (Appendix 7a).

Information provided within the brackets of each recommendation illustrates the clinical population from which the evidence was drawn. Given the number of gaps in the research literature, it is suggested that recommendations are considered with caution when applied to conditions or presentations other than that from which the evidence is drawn.

In this guideline, **splinting** will be the term used to describe the **process** of applying a prolonged stretch through the application of a range of devices. Most commonly, a **splint** is made from thermoplastic material. In addition, prefabricated splints are

sometimes used and are selected for or adapted to the individual. A **cast** is usually made from fibreglass casting tape or plaster of Paris; it is usually cylindrically applied and non-removable.

7.1 Lower limb recommendations

Correction and prevention of contracture in the lower limb can be a key clinical aim in the overall management of people who have altered activation as a symptom of a neurological condition. This section looks at the evidence base for the prevention and correction of contractures in the lower limb and is subdivided by joint area for ease of reference. The mean age of participants in the 16 lower-limb studies identified is 41 years. More men than women were included and the average study sample size was 34. Most people in the studies had an ABI. No studies in MS were identified.

7.1.1 Ankle

(a) Contracture correction

Recommendation 1
Ten studies graded from moderate to very low evidence that used casting to improve range of movement at the ankle joint (Booth et al 1983, Carda et al 2011, Lehmkuhl et al 1990, Moseley 1993, Moseley et al 1997, Pohl et al 2002, Singer et al 2003a, Singer et al 2003b, Verplancke et al 2005, Yasar et al 2010).

The majority of the 340 participants in the studies were people with ABI. Nine of ten studies were conducted in patients with chronic conditions; participants in the study by Verplancke and colleagues (2005) were a median of 10 days post-insult.

1. It is suggested that ankle casts are used at end range (for people with ABI and stroke) for improving range of movement at the ankle joint. 2C

   (Booth et al 1983 [D] ABI; Carda et al 2011 [B] stroke; Lehmkuhl et al 1990 [D] ABI; Moseley 1993 [C] ABI; Moseley et al 1997 [B] ABI; Pohl et al 2002 [C] ABI and stroke; Singer et al 2003a ABI [C]; Singer et al 2003b stroke and ABI [B]; Verplancke et al 2005 [B] ABI; Yasar et al 2010 [D] stroke)

Casts were changed as range improved every 5–7 days and applied for 2–12 weeks.

Recommendation 2
Five studies of moderate to very low quality used botulinum toxin A in conjunction with casts (Carda et al 2011, Farina et al 2008, Singer et al 2003b, Verplancke et al 2005, Yasar et al 2010). The majority of studies were in a chronic patient population; 92 of the participants had stroke and 45 had ABI.

2. It is suggested that ankle casts are applied at end range to improve joint range of movement in conjunction with botulinum toxin A (in people with stroke and ABI) when presenting with clinically significant spasticity. 2B

   (See also RCP 2009) (Carda et al 2011 [B] stroke; Farina et al 2008 [B] stroke; Singer et al 2003b; Verplancke et al 2005 [B] ABI; Yasar et al 2010 [D] stroke)

Casts were changed every 5–7 days and applied for 2–12 weeks.

Recommendations 3 and 4
Two studies from the USA used adjustable ankle splints to provide a prolonged stretch to increase range of movement at the ankle joint (Grissom and Blanton 2001, Lai et al. 2008). There were a total of 59 participants between the two studies; most of the people had a diagnosis of stroke. The reported incidence of adverse events (redness of skin and blistering) was high (44%) in the study by Grissom and Blanton (2001), which used prefabricated splints, and splints were removed only for hygiene purposes. There were no reported adverse events in the study by Lai and colleagues (2008), which used a custom-fit splint overnight for 6–8 hours. Both types of splint were adjusted regularly to maintain stretch at the maximum available range.

3. It is suggested that adjustable ankle splints applied at end range can be used (in people with stroke and ABI) for improving joint range of movement. 2C

   (Grissom and Blanton 2001 [D] stroke and ABI; Lai et al 2008 [C] ABI and stroke)

Splints were applied for 2–12 weeks and between 6–23 hours a day; splints were adjusted as range improved.

4. It is suggested that caution is exercised when considering the use of non-custom-made splints for the correction of contractures (at the ankle in people with stroke and ABI) due to the risk of pressure sores. 2D

   (Grissom and Blanton 2008 [D] stroke and ABI)

(b) Contracture prevention

Recommendations 5, 6 and 7
Two studies investigated the use of splinting for the prevention of plantarflexion contracture at the ankle joint. Conine et al (1990) examined the effect of serial casts for the prevention of contracture in a before-and-after trial of ten people with an average age of 28 years within 14 days of acute head injury. All participants had a Glasgow coma scale (GCS) score of less than 10 on admission and passive dorsiflexion of 0 degrees or less. Results indicated that the procedure was safe overall (one adverse event – a small pressure sore – was reported) and reasonably efficient in this carefully selected population.

5. It is suggested that ankle casts at end range dorsiflexion (in people with acute ABI) can prevent loss of range of movement. 2C

   (Conine et al 1990 [C] ABI)

Initially casts were changed as range improved every 5–7 days until patients were able to maintain plantar grade. The final cast at plantar grade was bivalved and worn for 18 hours a day as a resting splint to maintain range.

Robinson et al (2008) carried out a randomised controlled trial (RCT) to compare the effectiveness of a temporary night splint with prolonged standing on a tilt table to prevent loss of ankle movement early after stroke in 30 people. Results suggest that a night splint in this cohort of people was as effective as the tilt table in maintaining

range of movement. Compliance was 87% in the people who used the tilt table and 73% in the people who wore splints.

6. It is suggested that an ankle splint can be used for preventing the loss of range of movement at the ankle joint (in people with stroke) when positioned at plantar grade. 2B

   (Robinson et al 2008 [B] stroke)

The wearing time was 10 hours overnight for 2–5 weeks.

Two pressure sores were noted with the use of non-customised splints.

7. It is suggested that caution is exercised when considering the use of non-custom-made splints for the prevention of contractures (at the ankle in people with stroke) due to the risk of pressure sores. 2B

   (Robinson et al 2008 [B] stroke)

7.1.2 Knee

(a) Contracture correction

Recommendations 8 and 9

Three studies examined the use of casts to correct contracture at the knee in 33 people with ABI and stroke with a mean age of 30 years (Booth et al 1983, Lehmkuhl et al 1990, Pohl et al 2002). Most people received their first cast a minimum of six weeks post-neurological insult. The studies were all retrospective case studies undertaken between 1983 and 2002; they were all graded as low or very low quality. The studies reported fewer (8.8%) adverse events with the use of shorter-duration casts of 1–4 days, compared with 29.3% for the longer-duration casts of 4–7 days. Changes in cast materials that allow cast removal for inspection of the skin may help to reduce the rate of complications.

8. It is suggested that casts maybe used for the correction of contracture (in people with ABI and stroke) with the knee joint positioned at end range of movement. 2D

   (Booth et al 1983 [D] ABI; Lehmkuhl et al 1990 [D] ABI; Pohl et al 2002 [C] ABI and stroke)

Casts were changed as range improved every 5–7 days and applied for between 2–12 weeks.

9. It is suggested that short-duration cast application (1–4 days) may produce a lower complication rate than longer-duration cast application (4–7 days). 2C

   (Pohl et al 2002 [C] ABI and stroke)

(b) Contracture prevention

Recommendations 10 and 11

Only one study reported on the use of casts to prevent loss in range of movement at the knee joint in people with ABI and stroke (Pohl et al 2003). The study considered 68

people, with an average age of 45 years. The study used a retrospective case comparison design graded as low quality. Findings suggest more caution is required in the use of casts in acute patients with lower arousal levels.

10. It is suggested that casts at end range of movement at the knee joint may be used (in people with stroke and ABI) for the prevention of contracture. 2C

    (Pohl et al 2003 [C] stroke and ABI)

Casts were changed every 5–7 days and applied for between 2–5 weeks.

11. It is suggested that caution is used when considering casts for acute patients (with ABI and stroke) and at lower levels of arousal because of possible risks of secondary complications (e.g. pressure areas). 2C

    (Pohl et al 2003 [C] stroke and ABI)

7.2 Upper limb recommendations

This section is subdivided into two main sections: the wrist and hand, and the elbow. The participants (n=511) in the 19 upper limb studies (2 studies included both upper and lower limbs) had a mean age of 53 years. More men than women were included. The average study sample size was 27. In contrast to the lower limb studies, the vast majority of study participants were people with stroke. No studies in MS were identified.

7.2.1 Wrist and hand

(a) Contracture correction

Recommendation 12

Eleven studies graded from high to very low quality used splints to improve range of movement at the wrist and hand joints (Abdolvahab et al 2010, Amini et al 2009, Beaty and Murphy 2013, Bürge et al 2008, Charait 1968, Doucet and Mettler 2013, Fayez and Sayed 2013, Lannin et al 2007a, Lannin et al 2003, Leung et al 2012, Shamila et al 2011). The majority of the 264 participants in the studies were people with stroke. Four of the studies were conducted in acute patient populations, six in a longer-term chronic population, and one with a mixed sample. A wide variety of custom-made and off-the-shelf splints were used, including volar, dorsal, cone, finger spreader, hand mitt and cone. Wearing regimens, both times and joint position varied widely in the different studies.

12. It is suggested that splints should not be used routinely for the correction of range of movement but may be beneficial in selected cases (in people with stroke and ABI). 2B

    (Abdolvahab et al 2010 [D] stroke; Amini et al 2009 [D] stroke; Beaty and Murphy 2013 [C] stroke; Bürge et al 2008 [A] stroke; Charait 1968 [D] stroke; Doucet and Mettler 2013 [C] stroke; Fayez and Sayed 2013 [C] stroke; Lannin et al 2007a [A] stroke; Lannin et al 2003 [B] stroke and ABI; Leung et al 2012 [A] stroke and ABI; Shamila et al 2011 [D] stroke)

Splints were custom-made or serially adjustable (10 degrees wrist extension and finger extension, wrist at neutral, or maximal available range of movement). The majority were worn for between 20 minutes and 12 hours for between 1–8 weeks.

No studies using casts were identified.

(b) Contracture prevention

Recommendation 13
Six studies graded from high to very low quality examined the use of splinting for the prevention of contracture in the hand and wrist (Basaran et al 2012, Bürge et al 2008, Harvey et al 2006, Lannin et al 2007a, Lannin et al 2003, Shamila et al 2011). The majority of participants were people with stroke. Three of the studies were conducted in acute patient populations (Bürge et al 2008, Lannin et al 2007a, Lannin et al 2003), and three were conducted in a longer-term chronic population (Basaran et al 2012, Harvey et al 2006, Shamila et al 2011). No studies using casts were identified. Wearing times and joint positions varied widely in the different studies.

13. It is suggested that splints should not be used routinely to prevent loss in range of movement at the wrist and hand (people with stroke and ABI) but may be beneficial in selected cases. 2B

    (Basaran et al 2012 [B] stroke; Bürge et al 2008 [A] stroke; Harvey et al 2006 [A] stroke and ABI; Lannin et al 2007a [A] stroke; Lannin et al 2003 [B] stroke and ABI; Shamila et al 2011 [D] stroke)

Splints were applied in a variety of positions (10 degrees wrist extension and fingers fully extended, wrist at neutral, or close to maximal available range of movement). Splints were generally applied for 6–12 hours a day for 1–8 weeks.

Recommendation 14
One case-control study involving 65 participants used botulinum toxin A in conjunction with splints to ameliorate symptoms of spasticity and impairment, which can impact on range of movement (Carda and Molteni 2005). The study used taping to apply a prolonged stretch at the end of available joint range. Most participants were more than 3 months post-stroke.

14. It is suggested that splints in conjunction with botulinum toxin A (in people with stroke and ABI) may reduce spasticity as a component in preventing loss of range of movement in selected cases. 2C

    (Carda and Molteni 2005 [C] stroke and ABI)

Splints were applied at end of available range of movement but not adjusted daily. Strapping was applied at end of available range of movement, with daily adjustment to maximal stretch for 6 days.

Recommendation 15
A high-quality RCT involving 36 participants examined the use of electrical stimulation as an adjunct to splinting for the prevention of loss in range of movement and associated spasticity (Leung et al 2012). The majority of participants (average age 57

years) were 55 days post-stroke. People with contracture that prevented finger extension with the wrist in neutral were excluded.

15. It is suggested that electrical stimulation of wrist and finger muscles combined with a custom-made wrist and hand splint should not be used routinely to prevent loss in range of movement (in people with stroke or ABI). 2A

    (Leung et al 2012 [A] stroke and ABI)

The majority of splints were applied at end of range of movement and generally worn for 8 hours a day for 1–4 weeks.

Recommendation 16
Five studies graded from high to very low quality examined the use of splints in people with hand and wrist spasticity (Basaran et al 2012, Bürge et al 2008, Jung et al 2011, Leung et al 2012, Shamila et al 2011). Splint designs, wearing times and joint positions varied widely in the different studies.

16. It is suggested that a custom-made wrist and hand splint should not be used routinely to prevent the increase (or worsening) of spasticity (in people with stroke and ABI). 2B

    (Basaran et al 2012 [B] stroke; Bürge et al 2008 [A] stroke; Jung et al 2011 [C] stroke; Leung et al 2012 [A] stroke and ABI; Shamila et al 2011 [D] stroke)

Splints were all custom-made (10 degrees wrist extension and fingers fully extended, wrist neutral, or just off end range of movement). The majority of splints were worn for between 20 minutes and 12 hours a day for 1–8 weeks.

Recommendation 17
One high-level RCT investigated the effect of a neutral alignment custom-made splint on range of movement, pain, oedema and mobility (Bürge et al 2008). The 31 participants were post-stroke and had a mean age of 68 years.

17. It is suggested that a splint in a neutral wrist position may be beneficial (for people with stroke) for prevention of hand pain associated with joint malalignment. 2A

    (Bürge et al 2008 [A] stroke)

The splint was worn for a minimum of 6 hours a day for up to 13 weeks.

7.2.2 Elbow

(a) Contracture correction

Recommendations 18 and 19
Four studies graded from moderate to very low quality investigated the use of casts for the correction of contracture in the elbow (Hill 1994, Lehmkuhl et al 1990, Moseley et al 2008, Pohl et al 2002). Most participants had an ABI and were more than 6 weeks post-insult. Fewer adverse events were reported with the use of shorter-duration casts.

18. It is suggested that casts at end range are used (for people with ABI and stroke) for improving range of movement at the elbow joint. 2C

    (Hill 1994 [C] ABI; Lehmkuhl et al 1990 [D] ABI; Moseley et al 2008 [B] ABI; Pohl et al 2002 [C] ABI and stroke)

Casts were changed as range improved every 3–7 days and applied for between 1–4 weeks.

19. It is suggested that short-duration cast application (1–4 days) may produce a lower complication rate than longer-duration cast application (4–7 days). 2C

    (Pohl et al 2002 [C] ABI and stroke)

No studies using splints were identified.

Contracture prevention

No studies were identified that looked at the use of splints in the prevention of contracture at the elbow.

8 Informing evidence-based practice: practitioners' and service users' experience

8.1 Introduction

Numerous gaps were identified in the evidence during the literature review for these guidelines. Until more is known, therapists must continue to think carefully about their clinical practice. In keeping with the principles of evidence-based practice, therapists should justify their actions based on a combination of the published evidence, their clinical experience and patient preference (Sackett et al 1996). This section combines current practice from experienced therapists and insights from listening to service users on the realities of splinting. As practice should be assessed and evaluated formally, suggestions for outcome measures are also presented from systematic review, other areas of the literature and expert opinion.

8.2 Experiential evidence from practice

While developing the resources in this section, the clinical experience of occupational therapists and physiotherapists across the UK was drawn upon through the use of the Delphi method survey (Black 2006, Hasson et al 2000) over a period of four months. This approach was selected as the research tool of choice as it can help to achieve consensus in an area of uncertainty (see Appendix 3 for further details). The specific aim was to identify and gain consensus on factors that influence a clinician's decision on whether to instigate a splinting regimen as part of the overall approach to contracture management. In clinical areas where evidence was not available, consensus recommendations for practice are made based on the collective views, knowledge and experience of the GDG and on any other relevant documents, such as national clinical guidelines, where necessary.

There was a lack of consensus among therapists as to when to include splinting for contracture management in clinical practice. This is perhaps not unsurprising given the multitude of biopsychosocial variables that can influence a personalised approach to therapy intervention. There was strong consensus however, about when *not* to include splinting as a clinical intervention.

Table 8.1 and Boxes 8.1 and 8.2 outline the key considerations for and against splinting as part of a comprehensive goal-directed treatment and management plan for contracture.

Table 8.1 Key steps for consideration when splinting adults with contractures

Stage 1: Before considering splinting	• Splinting should be regarded not in isolation but as one part of a comprehensive goal-directed rehabilitation or management programme (RCP 2009). • If relevant, remediable provocative factors for spasticity should be addressed first (e.g. pain, infection) (RCP 2009).
Stage 2: Patient selection	• Patients suitable for splinting are those who may have, or may be at risk of, contractures and other treatment strategies are not maintaining joint range of movement. • Goals of intervention should be identified (e.g. improving range of ankle dorsiflexion or knee extension to enable standing or range of elbow extension to improve ease of dressing). • Splinting should not be considered in certain circumstances (Delphi Consultation 2013, ACPIN 1998, GDG Consensus), and caution is advised in others (see Boxes 8.1 and 8.2).
Stage 3: Agree action plan with team	• Identify the specific splinting intervention to be applied e.g. – cast or splint – bespoke or 'off the shelf' – design (e.g. consider pressure areas, lever lengths, materials used etc) – patient position to optimise application – wearing regime. • Identify the appropriately skilled person(s) responsible for making/provision of the splint or cast (ISWP 2012, NICE 2013). • Agree monitoring regime. • Identify outcome evaluation, including timeframes.
Stage 4: Before splinting	• Provide appropriate information to patients and carers (see example forms). • Obtain informed consent. In cases where an adult is unable to consent, a consultee process may be applied with the next of kin following discussion with the team, including medical colleagues, and a best interests decision made (COT 2010, CSP 2012). • Record baseline measures.
Stage 5: Splinting procedure	• Make or provide splint or cast.
Stage 6: Documentation	• Document consent or consultation process (COT 2010, CSP 2012). • Document splint or cast application details (see example in Appendix 6). • Document splint or cast monitoring regime (see example in Appendix 6). • Provide personalised application and monitoring information to patient and carers (see example in Appendix 6).
Stage 7: Review	• Plan review dates and outcome evaluation (NICE 2013).

Box 8.1 Identified factors for caution when splinting

When splinting is being considered caution is advised:

- If the patient has a vascular disorder.
- If the patient has a concomitant fracture or severe soft tissue injury.
- If the patient is medically unstable.
- If the patient is incontinent.
- If the patient is diagnosed with heterotopic ossification.
- If the patient has acute inflammation.
- If the patient is unable to communicate.
- If the patient has cognitive or behavioural problems.
- If access to the limb is needed for medical procedures.
- If there is uncontrolled intracranial pressure.
- If there is poor skin integrity.
- If there is oedema.
- If there is sensory loss or hypersensitivity.
- If there is fluctuating or severe tone or spasms.
- If there is a history of deep vein thrombosis.

(ACPIN 1998, Delphi 2013, GDG Consensus 2014)

Box 8.2 Factors to consider when splinting would *not* be advised

There was strong consensus in the Delphi survey (2013) for when splinting would *not* be indicated:

- If there is no identified benefit.
- If it causes pain or discomfort.
- If there is no clear plan for application, removal or monitoring of the splint.
- If other treatment strategies are working.
- If there is poor patient compliance.
- If there is a lack of follow-up.
- If the contracture has become established resulting in fixed joint deformity (See Appendix 3 for more details).

8.3 Key messages from service users summarised within the ICF framework

More detail of the service user involvement in the development of these guidelines can be found in Section 5.3 and Appendix 3. Key messages from service users and carers are grouped into positive and negative experiences under different ICF categories. These categories may assist therapists to consider user experience during goal setting as part of an overall rehabilitation or management programme.

8.3.1 Service users' experience of impairments (body structure and function)

Overall, patients described positive experiences in terms of improvement in impairment. This related specifically to improvement or maintenance in range of movement and reduction of spasticity.

> *"Until the serial casting started, getting my left heel down was always a struggle."* (Participant 4)
>
> *"Without the splint, hand is shrivelled up into a ball."* (Participant 2)
>
> *"[The splint] . . . takes the pain away from the wrist."* (Participant 5)

Therapists are reminded that caution is required when adjusting splints to gain range, as this can lead to adverse events:

> *". . . my wrist and hand swelled up when the splint was adjusted."* (Participant 7)

8.3.2 Service users' experience of activities and limitations

Participants described how activities could be made easier or harder with splinting. Some participants described how using splints helped them to resume playing music:

> *"Helps me to play the drums."* (Participant 4)
>
> *"Big brace I use for the piano."* (Participant 9)

In contrast, another service user reported on the downside of wearing splints: although they provided a stretch to help maintain range in their hands, they were potentially made more reliant on others for personal tasks:

> *"Once I've got [the splints] on . . . I can't move, I can't do anything . . . it's actually stretching everything . . . not possible to use in bed as need to use urine bottle."* (Participant 1)

The use of ankle splints, while helping to maintain range of movement, also provided stability for people when out and about:

> *"My leg splint is vital to me . . . Without this solid form I will fall over."* (Participant 3)
>
> *"Helps with getting in and out of the car."* (Participant 7)

The use of ankle splints came at a price for some participants:

> *"You virtually had to cut, sort of ruin, a pair of shoes to get it on."* (Participant 6)
>
> *". . . can't wear nice shoes, having to buy two pairs, one pair bigger to get the splint in; it's expensive and embarrassing, I wouldn't want to take a splint to a shop."* (Participant 9)

Service users described discomfort from splinting, especially when trying to sleep:

> *"Can't turn over in bed, so I am lying on my back . . . wake up in absolute agony . . ."* (Participant 4, serial cast foot)
>
> *'Sleeping at night is hindered by hand splint.'* (Participant 8)

The importance of sleep is essential, given that fatigue affects many people during rehabilitation and beyond (Mead et al 2007) and there is a potential link between disturbed sleep and depression and anxiety (ISWP 2012).

8.3.3 Service users' experiences of participation and restrictions

Examples were provided by service users on how splints, in particular those for the lower limb, helped them to participate more within their environment:

> *"When I travel it is a massive aid in my life."* (Participant 4)

Users also described negative impacts of splinting on participating in life roles, such as parenting and socialising with friends:

> *"Holding hands with children . . . it's quite bulky."* (Participant 3)
>
> *"People want to be able to go to formal occasions, they want to be able to wear a skirt or dress [wearing an ankle splint] . . . what do you do?"* (Participant 8)

Insights such as these provide powerful reminders of the wider impact of splinting not only on the individual but on the individual within his or her context.

8.3.4 Service users' experiences of environmental and personal factors

The ICF, as a biopsychosocial framework, takes into consideration the dynamic interaction of the individual with their environment, such as how features of the person's physical, social and attitudinal world can have an external influence on their disability, whereas personal factors reflect internal influences. Devices used in splinting are classified within the product and technology category of the environmental factors.

The following excerpts from service users describe their experiences of the splinting process first from the perspective of the environment and then personal factors are briefly considered.

How a splint or cast looked was important to many of the service users but appearance was not everything:

> *"It's ugly…but it is doing the job."* (Participant 8)

In contrast, other participants were conscious of wearing their splint in public:

> *". . . it's ugly, it is ugly . . . I wasn't wearing it out at all . . ."* (Participant 7)
>
> *". . . if I ever get out into the general public with them on . . . would not be a good look at all . . . it would put another label on me . . ."* (Participant 1)

Some service users explained they preferred their splint to have a 'sporty' look:

> *". . . this is more acceptable as could be for a sports injury . . ."* (Participant 1)
>
> *"[This one] is sporty looking . . . put on a pair of shorts and you look like you have had a sports injury."* (Participant 5)

Some service users commented on the colour of the splinting material; white featured on a number of occasions but for a variety of reasons:

> *"White is too medical."* (Participant 8)
>
> *"White is more neutral, draws less attention."* (Participant 4)
>
> *". . . if it's white or anything like that it gets grubby . . ."* (Participant 6)

The weight of the splinting device featured prominently:

> *"We take breaks during the day as it [arm splint] is heavy."* (Participant 3)
>
> *"It gets heavy . . . it is not easy lugging it [hand splint] around."* (Participant 7)

Given the potential long-term wearing of splints for some service users, it is important that services and systems are in place to monitor and adjust splints as required. Service users had mixed experiences:

> *". . . suddenly out of the blue it started rubbing, rang up and offered appointment, very quick."* (Participant 7)
>
> *". . . in hospital I was really skinny, when I got out I put on weight and the splint was too tight and had to stop wearing it."* (Participant 8)
>
> *". . . what is lacking is any kind of hospital aftercare."* (Participant 10)

Personal factors, which are described with the ICF as internal influences, are important to consider as part of the overall splinting process, especially given some of the challenges described by service users. Motivation to continue to wear splinting devices is a key internal resource and varies depending on individual circumstances:

> *". . . having a goal of recovery, I just thought it was going to help."* (Participant 8)

Whereas Participant 3, who has extremely limited functional hand and arm use, described the role of his family in motivating him to continue using his splints:

> *"I'm very distressed by not being able to hold my wife. I think my family's my greatest loss for me, and my greatest motivation."* (Participant 3)

8.3.5 Summary

The importance of listening to the experience of service users is evident from the insights shared in this section as part of the guideline development process. It is now incumbent upon therapists to incorporate these insights into practice.

8.4 Outcome measurement

All treatment interventions should have a formal assessment of outcome. It is suggested that outcome evaluation be considered when appropriate at a minimum of three levels (Ashford and Turner-Stokes 2013):

1. Goal attainment: have the intended goals for treatment been achieved?
2. Body system structure and function: has the splinting intervention produced an improvement or maintenance in range of movement?
3. Activity or function: Has this had any impact on function, either in terms of 'passive' (ease of care) or 'active' functional activity performed by the patient?

In some people it will be appropriate to consider whether the intervention has produced an improvement at the level of participation, wellbeing or quality of life for the individual or their carer. Evidence of cost-effectiveness is becoming ever more important.

While agreeing the goals for treatment with the individual and their family, the treating team should consider which measures would be appropriate to assess outcome and to ensure these are recorded at baseline and re-evaluated at defined intervals (Table 8.2).

8.4.1 Findings of systematic review for outcome evaluation

The systematic review identified measures applied in studies evaluating a splinting intervention (see Section 7 and Table 8.2).

The measures applied for upper and lower limb evaluation addressed aspects of body functions and structures, with the exception of patient satisfaction. The Functional Independence Measure (FIM), which is a measure of global activity, was used in two studies. No evaluation of participation was undertaken, and wellbeing and quality of life were not addressed. In addition, studies have not considered issues of cost-effectiveness.

8.4.2 Recommended outcome evaluation methods

Recommendations have been made using accepted or developing models of outcome evaluation in practice, with reference to the systematic review findings. Reference has also been made to systematic reviews and practice recommendations in other related areas of practice (Ashford and Turner-Stokes 2013, Ashford et al 2014a, Ashford et al 2008, RCP et al 2009) and to expert opinion in the GDG. The following model for outcome evaluation reflects this process and also includes suggestions for measurement tools that can be used in clinical practice or research.

(a) Have the treatment goals been achieved?

Clear goals for treatment should always be documented. Goals for intervention vary from patient to patient, and a single outcome measure cannot necessarily capture all domains.

Table 8.2 Key measures identified in splinting evaluation studies

Measure	Number of studies
Lower limb	**Total studies = 16**
Range of movement	14
Modified Ashworth Scale (spasticity evaluation)	4
Functional Independence Measure	2
10-metre or 6-minute timed walk (lower limb motor control)	2
Upper limb	**Total studies = 19**
Range of movement	16
Modified Ashworth Scale (spasticity evaluation)	8
Tardieu Scale (spasticity evaluation)	4
Fugl–Meyer Assessment (upper limb motor control)	4
Pain (Visual Analogue Scale)	3
Motor Assessment Scale	3
Grip strength (dynamometer)	2
Patient Satisfaction	2

Goal Attainment Scaling (GAS) is one method to record the successful attainment of one or more goals that are important to the individual. First introduced in the 1960s by Kiresuk and Sherman (1968), this technique was found to be suitable for health problems that warrant a multidimensional and individualised approach to treatment planning and outcome evaluation (Kiresuk et al 1994). It has been used successfully to demonstrate clinically important change in the context of focal spasticity management (Ashford and Turner-Stokes 2006, Ashford and Turner-Stokes 2008, Ashford et al 2014a) and in other areas of rehabilitation practice (Khan et al 2008, Turner-Stokes et al 2009, Wade 2009). Goal attainment is rated on a five-point scale and combined into a single score through the application of a standard formula. For example, has the splinting intervention produced an improvement or maintenance in passive joint range of movement?

It is important to assess the change or maintenance in passive range of movement (PROM) at the relevant joint: if splinting has not been effective at the level of body function, then it is unlikely that any activity gains may be attributed to the intervention.

It may also be appropriate to apply a clinical measure of spasticity if spasticity is identified as a particular problem for the patient undergoing intervention, such as the Modified Ashworth Scale (Bohannon and Smith 1987), Tardieu Scale (Gracies et al 2000) or Modified Tardieu Scale (Boyd and Graham 1999).

(b) Impact on activity (active and passive function)

Identification of functional improvements of benefit to service users (and sometimes formal and informal carers) should be assessed when appropriate. Standardised scales allow comparison between individuals and groups, therefore application of these tools may be particularly useful if group or service evaluation is being considered.

(c) Active function

Global measures such as the Barthel Index or the Functional Independence Measure are less likely to be sensitive to change arising from focal intervention such as splinting. Where patients have underlying selective voluntary movement in the limb, but contracture limits active function (e.g. by preventing standing and walking due to inability to extend the knee), improvement in the contracture may lead to improved active function. Evaluating this type of improvement, if it is anticipated, is then particularly important.

Measures of **upper limb** active function include:

- Action Research Arm Test (ARAT) (Koh et al 2006, Van der Lee et al 2002).
- Arm Activity Measure – Active Function Subscale (ArmA) (a patient-reported outcome measure) (Ashford et al 2014a, Ashford et al 2013a, Ashford et al 2013b, RCP et al 2009).

Measures of **lower limb** active function include:

- Rivermead Mobility Index (a patient-reported outcome measure) (Antonucci et al 2002, Collen et al 1991, Franchignoni et al 2003a, Franchignoni et al 2003b, Green et al 2001, Hsieh et al 2000, Johnson and Selfe 2004, Lennon and Johnson 2000, Pavan et al 2010, Roorda et al 2012a, Roorda et al 2012b, Ryall et al 2003, Schindl et al 2000, Sommerfeld et al 2011, Walsh et al 2010).
- 10-metre walking time or 6-minute walking distance (although not directly activity, the relationship to mobility in an activity context is accepted).

(d) Passive function

In some cases, there may be little possibility of restoring active function, but improving the ease of caring for the affected limb, for example in washing and dressing, can make significant impact on quality of life and carer burden. This type of outcome may also have cost benefits in reducing the time taken to provide care or the number of people required to perform care tasks.

Measures of **upper limb** passive function include:

- Arm Activity Measure – Passive Function Subscale (ArmA) (a patient-reported outcome measure) (Ashford et al 2014b, Ashford et al 2014c, Ashford et al 2013a, Ashford et al 2013b).
- Visual analogue and numeric rating scales.

Verbal or visual analogue ratings of 'ease of care' or timed care tasks, such as the time taken to dress or wash, could also be used to evaluate this type of outcome.

The GDG is not aware of any standardised measures addressing these issues in the context of **lower limb** splinting. Visual analogue or numerical rating scales may be used to quantify improvements in this context.

9 Implementation of the guideline

This practice guideline aims to support occupational therapists and physiotherapists to provide specific recommendations to support the judicious and considered use of splinting as an intervention for the prevention and correction of contractures in adults with a neurological dysfunction.

Familiarisation with the guideline document will be an important first step for individual practitioners and their managers. It is imperative that occupational therapists, physiotherapists and managers working in the area take responsibility to review the guideline recommendations within the context of their own practice.

Bringing the guideline to the attention of colleagues in the multidisciplinary team, service commissioners and other relevant people should also be a priority.

A further action to facilitate implementation must be for lead therapists to consider the facilitators and barriers within their local organisation and culture that may have an impact on any changes that may be necessary to practice. Section 9.2 identifies some potential barriers that may be applicable, while Section 9.3 provides details of resources to facilitate implementation.

9.1 Dissemination and promotion

To facilitate dissemination, the full practice guideline is available to download freely from the College of Occupational Therapists' website and the Chartered Society of Physiotherapy and the ACPIN websites.

Following publication, the guideline will also be promoted to its key target audience of occupational therapists, physiotherapists and relevant others using professional networks and publications, the internet and social media channels.

9.2 Organisational and financial barriers

The recommendations stated within this guideline document are intended to facilitate occupational therapy and physiotherapy staff to provide an effective and considered splinting service as an adjunct intervention, as part of a comprehensive goal-directed approach, for the prevention and correction of contractures in adults with a neurological condition.

It is recognised that potential barriers, both organisational and financial, may influence application of the recommendations. It is important that occupational therapists and physiotherapists take into account these barriers when implementing the guideline.

The recommendations are varied, but a potential issue impacting on implementation that may present across all recommendations is the availability of appropriately trained occupational therapists and physiotherapists within the multidisciplinary team (MDT). Ideally, this team includes orthotists and plaster technicians to support therapy

colleagues in patient rehabilitation and care. Staffing resources are therefore important in facilitating implementation. The following factors may impact on service provision:

- Increased throughput of service users.
- Introduction of a seven-day service.
- Ongoing climate of cost efficiencies.
- Increasing numbers of people receiving treatment.
- Different service settings, including care at home and other community settings.

9.3 Implementation resources

Three core implementation resources are available to support this practice guideline. All implementation resources can be downloaded, together with the full guideline document, from the Publications section of the College of Occupational Therapists' website (Practice Guidelines) and can be accessed from the Chartered Society of Physiotherapy and ACPIN websites.

Splinting is primarily a postgraduate clinical skill. As such, training costs are an additional resource requirement needed for the safe and appropriate implementation of these recommendations.

9.3.1 Quick reference guide

The quick reference guide lists the recommendations and indicates their strength and the quality of the evidence leading to their development.

This is intended to be used by practitioners as an easily accessible reminder of the recommendations for intervention. It should be ideally used once the practitioner has read the full guideline document. This is important to ensure an appreciation and understanding of how the recommendations were developed and their content.

9.3.2 Audit form

The audit form provides a template for individual occupational therapists and physiotherapists or services to audit and review their current interventions against the splinting process described in Table 8.1.

A baseline assessment conducted using the audit tool can be repeated to enable actions identified from the audit to be monitored.

The audit form, while initially providing a tool for use within an individual/service context, offers the potential for future benchmarking and wider comparative analysis.

9.3.3 Continuing professional development session

A set of PowerPoint slides and supporting documentation provides the resources for an individual or service to conduct a continuing professional development session focused on the practice guideline.

The learning outcomes for the session are:

- To explore aspects of the evidence-based guideline/ recommendations in relation to current practice.
- To develop an understanding of the importance of using an evidence-based guideline to inform practice.

- To explore and develop an understanding of how to use the College of Occupational Therapists' and Chartered Society of Physiotherapy ACPIN audit tool for the evidence-based recommendations.

The PowerPoint slide set can also be valuable in increasing awareness about the guideline, and additionally can be tailored to meet local needs.

A feedback form is also available to provide comment or updates to the College of Occupational Therapists and the Chartered Society of Physiotherapy (ACPIN).

10 Recommendations for future research

The review of the evidence has identified a lack of primary research in the UK and further afield on splinting in the prevention and correction of contractures. Potential areas for future research include:

- Dosage and wearing times.
- Identifying optimal methods of application.
- Investigating the effects of splinting across different joints, muscles and conditions.
- The use, choice and timing of outcome measures.
- Multicentre studies (i.e. RCTs).
- Role of splinting in MS and contracture management.
- Role of electrical stimulation and contractures.
- Splints and casts in combination with botulinum toxin type A and other therapy adjuncts.
- Identifying mechanisms research to understand more about what happens in the MTU.
- Clinical decision-making and thresholds for providing splinting.
- More exploration of user experience.
- Service delivery models for follow-up and review, including more integration with orthotics services.
- User-informed design of devices.
- Longitudinal studies on who develops difficulties with contractures and loss of movement.
- Long-term management of contractures as part of complex physical disabilities and postural management.

11 Updating the guideline

The National Executive Committees of COTSS-Neurological Practice and the Association of Chartered Physiotherapists in Neurology are responsible for ensuring future review of this guideline and will also provide a focal point for the respective professions for any feedback received on the guideline following its publication.

This guideline is scheduled for update by 2020; however, the review date may be brought forward if there is significant new evidence that may impact on practice.

Members of the National Executive Committees will be notified of any significant development in the evidence in the period before the review via their websites, newsletters and journals and an update on the evidence base presented at their annual conferences.

The wider membership of the British Association of Occupational Therapists and Chartered Society of Physiotherapy will also be made aware of any significant developments via the publications *OTnews* and *Frontline*.

Information about the College of Occupational Therapists Specialist Section-Neurological Practice is available at: http://www.cot.co.uk/cotss-neurology

Information about the Association of Chartered Physiotherapists in Neurology is available at: www.acpin.net

Appendix 1: Guideline development group and co-opted members

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Appendix 2: Acknowledgements

The GDG would like to thank all those who have contributed to the development of this practice guideline.

A2.1 Service users

Thank you to the service users and carers who agreed to be interviewed to share their valuable insights about their experiences of splinting.

A2.2 Stakeholders

Many thanks to the stakeholders for their time and insightful comments and suggestions: British Association of Prosthetists and Orthotists, Different Strokes, Headway, Multiple Sclerosis Society, Stroke Association, and Therapists in MS.

A2.3 External peer reviewers

Thank you to the external peer reviewers for their attention to detail and valuable suggestions when undertaking a peer review of the draft guideline:

- Dr Mary Cramp, Physiotherapist and Associate Head of Allied Health Professionals (Research Innovation and Knowledge Exchange), University of West of England, Bristol.
- Thérèse Jackson, Consultant Occupational Therapist, NHS Grampian, Aberdeen.
- Professor Anand Pandyan, Bioengineer and Professor of Rehabilitation Technology for Health, Keele University, Keele.

A2.4 Therapists

Thank you to the numerous therapists who have taken part, both formally and informally and whose comments and ideas have helped to shape this guideline. Thank you to those anonymous therapists who responded to the splinting survey (Kilbride et al 2013) that helped inform this guideline. Delphi participants who gave permission to be acknowledged in print are listed on p. 55.

A2.5 Additional thanks

The guideline development group would also like to thank the following:

- Members of ACPIN and COTSS-Neurological Practice who contributed their views and comments on the draft guideline during the consultation period.
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Appendix 3: Summary of the national Delphi method survey

This section summarises the Delphi method survey (Black 2006) with occupational therapists and physiotherapists, which was carried out over a 4-month period to explore factors influencing clinical decision-making for splinting adults with neurological conditions who have, or are at risk of developing, contractures. The specific aim was to identity and gain consensus on factors that influence clinicians' decision-making as to whether or not to use splinting, as part of the overall approach to contracture management. Ethical approval was granted by Brunel University London (reference number 13/10/STF/03).

Overview of the key points of the study

The survey was undertaken via email and used SurveyMonkey as the platform to collect the data across three rounds. The aim was to recruit 100 occupational therapists and 100 physiotherapists who were registered with the Health and Care Professions Council, were a minimum of Band 6, and were able to undertake splinting without supervision in practice.

Round 1

Participants were asked to:

- List up to five key factors that informed their clinical decision **to use** splinting.
- List up to five key reasons that informed their clinical decision **not to** use splinting.
- Provide a short explanation for each reason in an accompanying free text box.

Thematic content data analysis was undertaken by CK, JT, KH and TB. Ten per cent of the data were initially coded independently, and inter-judge agreement was calculated by an independent statistician using the kappa coefficient: reasons **to** use splinting = 0.877 and reasons **not** to use splinting = 0.974. Both sets of results indicated a very high level of agreement.

Round 2

Findings from Round 1 were presented back to participants, who were asked to rank in order of personal priority what they considered to be the five most important key factors concerning when to use and when not to use splinting.

Round 3

Participants were presented with the group rankings from Round 2 and asked to confirm or change the priority of the group rankings.

Results

The response rate was high across the three rounds with 218, 198 and 174 therapists, respectively, participating in each round. Most therapists (n=172, 79%) were Band 7 or above with nearly 50% (n=104, 47.7%) having been qualified for 15 years or more. Most (n=172, 78%) worked in an inpatient setting (acute n=70, 31%; rehabilitation n=102, 46.8%), followed by n=144, 66% outpatients (31.7%, n=69) and/or community (34.4%, n=75) (can work across settings so higher number). The majority of people were employed by the NHS (79.4%, n=173); Private (11.5%, n=25); Charity (6.9%, n=15); self employed (9.6%, n=20).

Therapists reached a **poor consensus** on when **to use** splinting (W=0.115) but a **good consensus** on when **not to use** splinting (W=0.732).

Key factors identified for when *TO* use splinting (poor consensus between therapists)

To protect a joint	*Use splinting to protect the integrity of the joint e.g. a subluxed/hyperextended joint*
In the presence of increased activation	*Use splinting if there are signs of increased activation/ spasticity/hypertonia*
To improve joint alignment	*Use splinting to improve alignment e.g. resting splints*
To promote comfort and manage pain	*Use splinting to promote comfort and/or manage pain*
To increase range of movement	*Use splinting to increase range of movement*
To enable active function	*Use splinting to help assist with or achieve a functional activity e.g. grasp and release, standing, walking*
To promote personal hygiene and skin integrity	*Use splinting to assist with maintaining personal hygiene and integrity of skin*
An adjunct to anti-spasticity medication	*Use splinting as an adjunct to botulinum toxin or other anti-spasticity medication*
To maintain or prevent	*Use splinting to maintain range of movement or prevent further loss of range of movement*

Key factors identified for when *NOT* to use splinting (good consensus between therapists)

No identified benefit	*Do not use splinting if there is no identified goal or benefit*
Pain or discomfort	*Do not use splinting if it causes pain, discomfort, cannot be tolerated or aggravates present condition i.e. it increases tone*

Unable to apply, remove or monitor	*Do not use splinting if unable to independently put on and take off splint and self-monitor skin or does not have anyone to help with this*
Poor skin integrity	*Do not use splinting if there is poor skin integrity*
Other treatment strategies are working	*Do not use splinting if other treatment is/are working to achieve aim i.e. splints should not be used as a first line option*
Restrict activity/ movement	*Do not use splinting if it restricts returning movement or limits ability to perform an activity*
Oedema	*Do not use splinting in the presence of fluctuating/ severe oedema*
Poor patient compliance	*Do not use splinting if there are issues with compliance e.g. impaired cognition, behavioural problems*
Lack of follow-up	*Do not use splinting if there are insufficient resources to enable appropriate follow-up/review*
Altered sensation	*Do not use splinting if sensory loss is such that it would cause problems e.g. with skin integrity or increased hypersensitivity*
Fixed contracture	*Do not use splinting if contracture is fixed*
Fluctuating/severe	*Do not use splinting in the presence of fluctuating tone or severe tone*

Appendix 4: Summary of key findings from service user consultation

(Ethics approval reference number 13/10/STF/03 – Brunel University London)

An integral part of developing evidence-based guidelines for splinting is the involvement of users and carers who know what it is like to use splints and casts as part of rehabilitation and everyday life. Knowledge about users' experience can help improve collaboration between users and professionals, which has been noted to be key to the implementation and development of successful interventions (Radomski 2011). There is a paucity of research, however, into users' experience on splinting (Andringa et al 2013, Kuipers et al 2009). Studies conducted in the Netherlands (Andringa et al 2013) and the USA (Beaty and Murphy 2013) explored users' experience in stroke and concluded more qualitative in-depth exploration was required. To this end, a sample of ten people and two carers participated in semi-structured interviews to explore the lived experience of splinting for the management and prevention of contractures in people with neurological conditions. Data from participants with carer involvement were treated as a dyad (i.e. analysed as a pair). Participants were recruited from local support and charitable organisations; their characteristics are shown in Table A4.1.

Inclusion criteria were:

- Adults aged 18 years and over with a diagnosis of stroke, or MS or TBI and able to give informed consent.
- Experience of wearing a splint in the past year as part of treatment and management of those people at risk of, or with, contracture as a result of their neurological condition.

Table A4.1 Participants' characteristics

ID	Gender	Neurological insult	Age range (years)	Time post insult	Joint areas	Customised or-off-the shelf splint
P1	Male	MS	50–59	14 years	Wrist and hand	Both
P2	Male	Stroke	30–39	4 years	Wrist and hand, ankle	Both
P3	Male	TBI	40–49	3 years	Elbow, wrist and hand, knee and ankle	Both
P4	Male	TBI	30–39	7 years	Wrist and hand, ankle	Both
P5	Male	Stroke	30–39	9 months	Wrist and hand, ankle	Both

ID	Gender	Neurological insult	Age range (years)	Time post insult	Joint areas	Customised or-off-the shelf splint
P6	Female	Stroke	60–69	10 years	Wrist and hand, ankle	Both
P7	Female	Stroke	30–39	4 years	Shoulder and elbow, ankle	Both
P8	Female	Stroke	40–49	1.5 years	Wrist and hand, ankle	Both
P9	Female	TBI	40–49	8 years	Wrist and hand, ankle	Both
P10	Male	Stroke	40–49	2 years	Wrist and hand, ankle	Both
ID	Gender	Relationship to participant				
C3	Male	Paid carer	20–29			
C10	Female	Wife	40–49			

The indicative guide for interviews included the previous or current use of splint/cast, comfort, and specific design of the splint, including style, fit, colour and acceptability. Self-reported difficulties with the limb was also explored to place the use or non-use of the splint/cast in context with perceived limitations, including muscle tightness (spasticity), skin hygiene, comfort, pain, oedema, and use of the arm or leg in function (such as in activities of daily living, transferring in and out of bed and chairs, standing and walking).

All data were transcribed verbatim, and transcriptions were checked against the original recordings. Data were analysed using an analysis framework (Spencer et al 2014). Another member of the research team independently reviewed the process of coding, first theme identification and development of the overarching themes, supporting the rigour and transparency of the process. The findings and participant quotes were used in Section 8 to provide the users' voice and evidence. It is planned that the study will be published in full in a peer-reviewed journal.

Appendix 5: Literature search strategy

CINAHL search terms

S1	Splint* or cast or casts or casting or orthos*s
S2	Physiotherap* or 'physical therap*'
S3	((Brain or head) and injur*) OR (stroke or CVA or cerebrovascular accident) OR ('multiple sclerosis' or ms) OR neurolog*)
S4	((Brain or head) and injur*) OR (stroke or CVA or cerebrovascular accident) OR ('multiple sclerosis' or ms) OR neurolog*) AND (S1 AND S2 AND S3)
S5	(brace* or bracing) OR S1

This search was repeated with 'Occupational Therap*' replacing 'Physiotherap*' or 'physical therap*'.

Medline search terms

S1	Physiotherap* or 'physical therap*'
S2	((Brain or head) and injur*) OR (stroke or CVA or cerebrovascular accident) OR ('multiple sclerosis' or ms) OR neurolog*)
S3	(splint* or cast or casts or casting or orthos*s) OR (brace* or bracing)
S4	S1 AND S2 AND S3

This search was repeated with 'Occupational Therap*' replacing 'Physiotherap*' or 'physical therap*'.

AMED search terms

1	((splint* or (cast or casts or casting) OR (brace* or bracing) or (orthosis or orthoses)).af.
2	(physiotherap* or 'physical therap*).af.
3	((Brain or head) and injur*) OR (stroke or CVA or cerebrovascular accident) OR ('multiple sclerosis' or ms) OR neurolog*).af.
4	1 and 2 and 3

Asterisks (*) were used as a wild card symbol for truncation.

Appendix 6: Sample documentation

Sample patient information

How to look after your splint/cast

What is a splint/cast?
A splint/cast is a personalised supportive device to help you stretch or support a joint as part of your rehabilitation plan.

Why have I been given a splint/cast?
Splints/casts are used to improve or maintain range of movement at a joint. Make sure you are clear as to why this is useful for you, for example to stretch a part of your body or to reduce pain.

When should I wear my splint/cast?
You should agree when to wear your cast and for how long with your therapist. Often this timeframe increases as you become used to wearing it.

○ You agreed to ……

Things to watch out for
Please check your skin after you take off the cast for unusual signs, such as:

- Swelling
- Pain
- Redness
- Numbness
- Pins and needles
- Stiffness
- Skin rash

If you think the splint/cast has caused any of these problems, then either ask for it to be removed or stop wearing it and please contact your therapist.

○ #### What should I do if there is a problem with my splint/cast?
If it breaks or needs reviewing, please contact your therapist.

Cleaning my thermoplastic splint [add or remove as appropriate]
Remove straps and wash in warm soapy water. Dry before wearing again. Note that the shape of your splint can be affected by direct heat, such as a hot radiator.

Any other questions?
Please contact your therapist at:

Address of department:

Therapist's name:

Telephone number:

Splint-wearing timetable

- Splint to be worn as indicated by shaded area on timetable.
- Tick the time and initial when putting on and tick the time and initial when removing, having checked for potential pressure areas.

Patient name:		**Who can put on/remove splint?**	
Named clinician:		**Signature:**	**Initial:**
Description of splint:		**Signature:**	**Initial:**
		Signature:	**Initial:**
		Signature:	**Initial:**

Time	**Monday (date)**		**Tuesday (date)**		**Wednesday (date)**		**Thursday (date)**		**Friday (date)**		**Saturday (date)**		**Sunday (date)**	
	Tick/ shade	**Initial**	**Tick/ shade**	**Initial**	**Tick/ shade**	**Initial**	**Tick/ shade**	**Initial**	**Tick/ shade**	**Initial**	**Tick/ shade**	**Initial**	**Tick/ shade**	**Initial**
08:00														
09:00														
10:00														
11:00														
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15:00														
16:00														
17:00														
18:00														
19:00														
20:00														
21:00–08:00														

Therapist Notes

Monitoring advice for prevention of adverse events

- Any staff putting on or removing a splint should check the skin for potential pressure areas.
- The splint must be removed if any adverse signs are noted, such as redness, skin breakdown, swelling, skin discoloration, or visible or reported discomfort by the patient.
- The named clinician to be informed as soon as possible.

Appendix 7: Evidence-based review tables of included studies and evidence tables of critically appraised systematic reviews

(a) Evidence-based review tables of included studies

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if applicable)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Abdolvahab et al (2010) (Translated paper from Persian)	Before and after repeated measures Aim: evaluate effect of volar splint on spasticity & function of adults with stroke n=15 (5M &10F) Age 41–85 (mean 57.66 years) 3.26 years post stroke (range 1–7 years) 1 year post-stroke MAS 1–2 in elbow & wrist joints Hospital and rehabilitation centres Iran	Volar static thermoplastic splint – wrist 10° ext, full ext fingers, abd & opp of thumb Plus usual care including neurodevelopmental treatment Dose = 2hrs/day & 4 hrs/night for 2 months	No control group	Spasticity – MAS Function – FMA PROM wrist & elbow – goniometer Measures taken at weeks 0, 2, 4, 6, 8	Wrist joint spasticity improved: pre 2.73 ± 0.59 – post 1.60 ± 1.12 ($p<0.0001$) & elbow joint spasticity improved pre 2.26 ± 0.45 – post 1.26 ± 0.88 ($p<0.0001$) Function UL improved: pre 26.20 ± 15.58 – post 37.20 ± 15.56 ($p<0.0001$) PROM wrist improved: pre 39.33° ± 11.93 – post 71.66° ± 8.79 ($p<0.0001$) PROM elbow improved: pre 118° ± 20.51 – post 128.33° ± 6.98 ($p<0.002$)	Grade D – very low Downgraded from Grade C due to limitations: Risk of bias high Limitations in study include: • Small convenience sample • No control group • Assessor not blinded • Co-intervention • No reliability data • Drop outs not reported • FMA not OM of function Although improvements are seen with splinting in this study, the limitations of study considerable and risk of bias very high Overstated claims given level of confounding factors and high risk of bias.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if applicable)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Amini et al (2009). (Translated paper from Persian)	Pre, post test Aim: to examine effect of volar-dorsal splint on function of UL, ROM (elbow, wrist, MCP joints) & spasticity in wrist & elbow Stroke – min 1 year post n=14 (7M, 4F) Age 20–64 (mean 52.64 ± 9.41) Hand spasticity ≤ 3 MAS No similar splints or botulinum toxin injections OT clinic – Iran	Volar-dorsal hand splint – wrist held in 10°ext, fingers 0°, thumb "hyper abduction" Plus routine OT 3 × week for duration of study Dose = 2 hrs/day, 6–8hrs/night for 1 month	No control group	Spasticity: elbow & wrist – MAS Function – FMA ROM (passive and active): elbow, wrist, MCP – goniometer	11 people completed, 3 did not complete follow up ITT analysis not evident No change in ROM or spasticity (p>0.05) Significant difference in UL function p=0.04 (Mean dif 2.09 ± 2.98, t=–2.32)	Grade D – very low Downgraded from Grade C due to limitations: Clinical significance of functional change not discussed; FMA is a measure of impairment Risk of bias high, limitations include: • Small convenience sample • No control group • Assessor not blinded • Co-intervention • No reliability data • Data excluded for dropouts • FMA not OM of function Some indication of improvement in function but not in spasticity or range of movement but small study with high risk of bias Overstated claims given level of confounding factors and high risk of bias.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if applicable)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Basaran et al (2012)	Single blinded randomised controlled trial Aim: determine effect of volar & dorsal splinting on wrist flexor spasticity (+ range of movement) n=39 (22M & 16F, + 1 unknown) Single stroke, wrist MAS ≥ 1+ Age 26–81 (mean 55.6 years). Mean 38 months post-stroke (range 5–120) Could be on antispasticity medication if not changed for last 1/12 Exclusion included if worn splint within 8/52 Turkey, Rehab hospital (outpatients)	Expt groups: Dorsal splint (DS) (n=13) Volar splint (VS) (n=13) All: home based exercise programme (including stretch wrist and finger flexors × 10 × 3/day) Dose = splint to be worn up to 10 hours overnight for 5 weeks *splinting position – beyond angle of 'catch', plus modified by 10° if stretch too much	No splint (NS) (n=12) Plus home exercise programme (all groups)	Spasticity: MAS (6 levels) & H latency & Hmax: Mmax ratio PROM wrist extension – double armed goniometer Measures before & after (5 weeks) at least 2 hours post-removal of splint Only electrophysiological measures were blinded	No significant differences reported in any paradigm MAS –15 ± 0.55 (DS) –15 ± 0.69 (VS) –0.17 ± 0.58 (NS) PROM 2.31 ± 8.07 (DS) 3.46 ± 7.18 (VS) 0.42 ± 4.5 (NS) Time splint worn: 7.69 ± 1.72 (4–10) (DS) 7.15 ± 1.84 (4–10) (VS)	Grade B – moderate Downgraded from Grade A due to limitations: Attempts to reduce bias: • Control group • Random allocation process • Blinded assessor (electrophys OMs only) • Drop outs reported Limitations include: • Small sample • Assessor not blinded (MAS, PROM) • No reliability data • Co-intervention not monitored Overall no effect on spasticity, suggests dose not long enough. As primary study aimed at spasticity levels and not PROM, splints were not to end range of muscle which maybe more effective.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if applicable)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Beaty and Murphy (2013)	Single Case Experimental Design (ABAA) Aim: Does a flex orthotic splint improve ROM? Convenience sample n=8 (5 stroke, 2 joint contracture, 1 RA) All had hand contracture 4M, 4F, aged 57–91 (mean 76.4 ± 10.5) USA – nursing home for older adults	Flex orthotic splint (custom made) Dose = 8 hrs/day for 8/52	n/a	RoM – flex/ext of hand joints (goniometer) (OTs blinded to measurements) Measures taken before, midpoint (2 sets) and end of study. Satisfaction survey (e.g. ease of wearing/ removing splint, comfort etc)	18/28 joints (64.3%) significant change over 8/52 14/18 (77.8%) = positive change4 = negative change (DIP 5th, 4th, 2nd, and adb thumb) (see paper for individual results, too many to report) Satisfaction survey (n=7) – overall positive, greatest difficulty removing splint. Open comments – mixed reviews	Grade C – low Interesting study, user comments re using splints. Some indication of increasing ROM (all participants had contractures) Results must be viewed with caution: • High risk of bias in study • Lack of control group • Small sample size, underpowered study. • Different assessors for each measurement point (attempt to blind).

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if applicable)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Booth et al (1983)	Retrospective case series Aim: Evaluate the effectiveness of casting knee or foot Records from 201 patients admitted to an adult head injury service were reviewed 21% underwent casting (cortical lesions most frequent, followed by brainstem ± cortical n=42, mean age 23 yrs Acquired brain injury USA	Serial casting (knee or foot) Dose – 7–10 days between cast changes (Worn 7–92 days) Mean 78 days from time of injury to first cast	No control group	Measures: Range of Movement (ROM) Scale for resistance to passive stretch (for muscle tone) Recording: – Frequency of cast application – Results of lower extremity serial casting	Long leg casts (knee, ankle and foot): (n=5) Mean improvements in ROM (mean 17–26°) and Muscle Tone Short leg casts (ankle and foot): (n=39) Mean improvements in ROM (27° and 15°) and Muscle Tone NB: some overlap seems to be indicated with a small minority of patients having both long and short leg casts	Grade D – Very low Downgraded from Grade C due to limitations • Early study identifying possible clinical benefits through description and clinical audit • High risk of bias • Requires evaluation of results before consideration for practice.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if applicable)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Bürge et al (2008)	Randomised controlled trial Aim: Quantify preventative effect of neutral functional realignment orthosis on ROM, pain, mobility & oedema n=31 (1 withdrew post-group allocation), Expt: n=16, age 68 ± 12, M6, F9, 29 days ± 15.7 (15–74) post-stroke Control: n=15, mean age 64 ± 14, M5, F10, 30 days ± 12.1 (12–57) post-stroke Inpatient rehab centre Switzerland	Standard rehabilitation + realignment orthosis (custom made splint by OT) Dose: splint (neutral position) worn min 6 hrs /day up to 13 weeks Rehab: 2 × PT/day, 1 × OT/day plus SLT and psychology if needed	Standard rehabilitation only Rehab: 2 × PT/day, 1 × OT/day plus SLT and psychology if needed	FMA – ROM (forearm, wrist & hand) MAS – wrist ext tone VAS – Hand pain at rest Wrist circumference – oedema Verbal – Patient satisfaction	Pre – 2 patients in each group c/o painful hand Post – 8 patients in control group had pain, 1 patient in expt group (p=0.004) ROM, MAS & oedema – no statistically significant change May have preventative effect on post-stroke hand pain but not mobility or oedema Subanalysis = wearing splint ≥ 10 hrs same as 6 hrs	Grade A – High Well conducted study: • Random concealed allocation • Groups well balanced • Control group • Reliability data • Blinding in practice difficult as patients spoke about splint Some indication for use of hand splint for prevention of hand pain post stroke but more replication of study required.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if applicable)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Carda and Molteni (2005)	Case-control study Aim: To evaluate the effectiveness of electrical stimulation on write and finger spasticity after botulinum toxin injections n=65 Stroke (n=55), TBI (n=7), other CNS (n=3) ≥ 3 months post insult Age 18+ Italy	Botulinum toxin (BTX) Product: Botox Group 1: BTX + Strapping – dose = 6 days taping Group 2: BTX + Splinting and FES + stretching exercises	None	Modified Ashworth Scale (MAS)	Both groups improved significantly However group 1 had significantly better reductions in spasticity than group 2 (MAS)	GRADE C – low High risk of bias. • Significant limitations in measurement in only evaluating spasticity outcome. No blinding of assessor • No random allocation (based on hospital attended) • Does not support the use of splinting in combination with functional electrical stimulation.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if applicable)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Carda et al (2011)	Single-blind, randomised trial, with three-month follow-up. Aim: To evaluate the effectiveness of casting, taping or stretching after botulinum toxin type A for spastic equinus foot. n=69 Stroke Average 47.7 (41.5 SD) months since stroke Mean age 62.1 Italy	Post botulinum toxin type A injection in plantar flexors, patients randomly assigned to 3 groups and received either: – taping, – casting or – stretching for one week + stretching & gait training for next week	3 intervention groups, no control group	T1 20 days, T2 90 days MAS PROM at the ankle Six-minute walking test 10-metre walking test, Functional Ambulation Categories (FAC) Ankle dorsiflexor strength	Significant improvement in the casting group at all timepoints for PROM, MAS, 6 minute walk, 10m walk Taping – all significant at T1, only MAS & 6 min walk at T2 Ankle DF strength & FAC no changes at any timepoint	GRADE B – moderate Downgraded from Grade A due to limitations: • Some risk of bias, but reasonably robust study with single blind design. • Groups similar at baseline • Blinded assessor • Computer randomisation • Provides evidence for the effectiveness to serial casting in adult stroke patients for the ankle joint.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if applicable)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Charait (1968)	Before and After (pilot) Aim: A comparison of volar and dorsal splinting of the hemiplegic hand n=20 (10 = volar; 10 = dorsal) 10 M; 10 F, aged 30–80 years 9 R hemiplegia 11 L hemiplegia Splint applied post stroke 4 days to 6 years. USA – rehab inpatients and outpatients	Volar or dorsal splint Dose = 2 to 23 hours per day (removed for therapy and bathing) Usual care = passive or active ROM exercises, average 30 mins/day × 5/week, plus OT (incl graded resisted ex's), 30 mins/day × 3/week	No control group	Spasticity – clinical observation Range of movement: wrist and finger extension – not stated how measured	Volar splints – increased spasticity in 6 (4 marked), 4 no change in spasticity or voluntary movement Dorsal splints – no change in outcomes in 1; one considerable increase in spasticity, 8 decrease spasticity (4 with improved active finger & wrist extension)	Grade D – very low Downgraded from Grade C due to limitations Early study that engaged with the splinting debate at the time; high risk of bias. Uncontrolled study with multiple biases including sample/selection, measurement Patients who showed best results only wore splints at night. All patients wearing splints for 23 hours complained of pain in hand and entire arm.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if applicable)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Conine et al (1990)	Prospective case series, before and after (pilot) Aim: To examine the effect of serial casting for prevention of equinus in patients with acute head injury n=10 (8 M; 2 F) (18 limbs, 16 bilateral) Average 28 years, GCS < 10 on adm PROM DF ≤ 0° Inpatient acute care Canada	Serial casting within 14 days of TBI plus usual care Dose: cast removed after 5–7 days Cast replaced if unable to maintain DF at ≥ 0° for 1 hour Final cast bivalved & worn 18 hours/day (4 hr on/1 hr off)	No control group	1PROM DF of ankle – goniometer 2Skin condition – visual inspection Inter-rater reliability Blinded assessor	Mean gain pre-post cast = 21° p<0.05 13/18 limbs reached PROM DF of ≥ 0° (maintained without force for min 1 hr) Adverse event – 1 small pressure sore Conclusion: procedure appears safe, reasonably efficient in carefully selected population.	Grade C – low Well carried out study within design limitations. • Small sample size • Inherent biases in study design (e.g. no control group, not randomised) • Co-intervention • Need longer term follow up • Need RCTs to further assess efficacy of casting.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if applicable)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Doucet and Mettler (2013)	Case series design (before & after) on a single subgroup Aim: To evaluate effect of 12-week dynamic progressive orthotic splint on people with stroke + wrist flexion contracture n=6, 4F, 2M Mean age 61 years (range 53–71), min 1 year post stroke 1/5 on Modified Ashworth Scale Nursing home facility USA	Custom fitted serial adjusted wrist extension orthotic / splint *(Dynasplint) Dose: 4 hours/day, 4/ week for 12/52 (NB: dynasplint recommend 6–8hrs/ day) * fitted and adjusted periodically by Dynasplint representative to obtain max comfortable wrist extension Investigators put splint on and off each day	No control group	1PROM wrist – goniometer 2RTPM (resistance to passive movement) – MAS and Modified Tardieu Scale (MTS) 3Surface EMG – RTPM Inter-rater reliability (ICC 0.76) Blinded assessor (to study objectives) took measures weekly (baseline established), & 2, 4 & 6 weeks post-intervention	5/6 people showed increased PROM and decrease in RTPM A moderate effect size found PROM pre-post 0.67, PROM post retention 0.60 EMG burst onset 0.62 (indicates less RTPM) MAS, MTS – min effect sizes Conclusion: Dynasplint can be effective in increasing wrist ext in people with chronic stroke + flexion contracture and decreasing RTPM Compliance assisted by investigators donning and doffing splint throughout study	Grade C – low Well carried out study within design limitations. • Small sample size • Inherent biases in study design (e.g. no control group, not randomised) • Need RCTs to further assess efficacy of dynasplint. Also to investigate if recommended dose of 6–8 hrs daily better than the 4hr/day Suggests can effect non-neural aspects of RTPM but not neural.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if applicable)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Farina et al (2008)	Randomised study design. Aim: To evaluate the combined effects of botulinum toxin and casting treatments on lower limb spasticity after stroke Patients with equinovarus foot randomised to two groups n=13 Stroke – 6/12 to 2 years post stroke Italy	Group 1 botulinum toxin A (BTX) injection plus ankle-foot casting (n=6) Casts (removable) were worn at night for four months	Group 2 BTA alone (n=7). No control group	Static and dynamic baropodometric Tests Modified Ashworth Scale 10-metre walking test	Between groups: Small significant differences seen in support area during gait and in spasticity but clinical significance doubtful No significant difference in 10 metre walk	Grade B – moderate. Downgraded from A due to limitations: • Some weaknesses in the study (possibly also in the casting intervention, although not possible to confirm) • Some aspects of reporting, such as description of sampling missing • Lack of demonstration of clinical significance and applicability of findings.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if applicable)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Fayez and Sayed (2013)	Randomised controlled trial Aim: To evaluate the influence of different Types of Hand Splints on Flexor Spasticity in Stroke Patients Stroke n=29, min 6/12 to 1 year post stroke 45–65 years Egypt	Two groups Group 1: Static splint (custom made): Cotton tissue splint Group 2: Dynamic splint: Custom made thermoplastic Both group applied splints for 1 hour per day only	No control group	Active range of movement (A–ROM) Passive range of movement (P–ROM) Grip strength – digital dynamometer	Both groups showed significant improvements from baseline in all three measures Significant between group differences for A-ROM and P-ROM at outcome	Grade C – low (downgraded from grade A) • The general reporting of the study poor. No reporting of randomisation, how measurements were performed • The very short duration of intervention, results in the work not addressing clinically relevant or applicable intervention.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if applicable)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Grissom and Blanton (2001)	Prospective non-randomised intervention trial (before & after pilot) Aim: assess effectiveness of adjustable AFO splint in treatment of PF contracture in CNS damage or disease n=6 (2M, 4F) stroke, TBI, ICH, AVM (9 ankles) Age 21–62 PROM DF ≤0°, <5° change PROM post 2% lidocaine block (to differentiate between spasticity & contracture) Inpatient acute care USA	Adjustable AFO splint (pre-fabricated commercially available) plus usual care Adjustment of angle of orthosis from 0° to 4.5° every 48–72hrs as tolerated. Dose: 23/day for 14 days (only removed for hygiene purposes)	No control group	DF PROM with knee extension – goniometer (ICC intra-rater >.90) Unblinded assessor	Increased PROM average (pre/post) 20.1°, range 6–36° (p=0.0078) 5 completed study (1 drop out, concerns about increased agitation in person with TBI) Adverse events: 44% ankles reported redness of skin, or blister formation with pain Conclusion: PF contractures can be reduced with adjustable AFONB – careful monitoring required as high rate of adverse events	Grade D – very low. Downgraded from Grade C due to limitations Limitations in keeping with study design including: • Lack of blinding of assessors • No control group • Co-intervention • Lack of standardisation of force to achieve DF of ankle • Small sample Very small study with some indication of increased passive dorsiflexion. Results need to be duplicated in RCTs and larger cohorts.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if applicable)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Harvey et al (2006)	Randomised controlled trial – within and between design Aim: To evaluate the effectiveness of night splints on thumb webspace contractures n=44 participants (60 thumbs incorporating bilateral intervention in some people) 14 stroke, 7 TBI, 23 SCI Median age 54 (IQR 43 to 65) Median time since onset 4 years (IQR 2 to 10) 55 thumbs 0 or 1, 5 thumbs 2 or 3 (Ashworth) Australia – inpatients and outpatients	Thermoplastic splint to keep thumb in abduction (c splint or cone splint). Text implies stretch at end of range Dose – 12 weeks, overnight 8 hours/ night (minimum of 84 nights) Experimental and control groups told not to stretch, no other intervention received. Expt group received phone call 1–2 weeks to monitor compliance Splints reviewed at 1, 4 and 8 weeks	Control – no splint to stretch thumb web space, no contact over 12 weeks (NB: n=10 had old splints modified to exclude thumb from stretch and allowed to wear)	Baseline, 12 weeks (one day post study) Palmar abduction of CMC joint – customised device to apply standardised force MCID set at 5° a priori at CMC joint	1 drop out (2 thumbs) No sign difference between groups at baseline Mean increase 1° (95% CI, –1 to 2) Adverse events reported: minor problems with skin breakdown (median 4 out of 84 nights missed due to skin related problems)	Grade A – high Well conducted study: Random allocation blocked to diagnosis (post baseline), Concealed allocation, Assessor blind Power calculation Results indicate that in this study, stretched over 12 weeks does not change tissue extensibility in the thumb web space.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if applicable)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Hill J (1994)	Randomised case control cross over trial Aim: To evaluate the effects of casting on upper extremity motor disorders after brain injury Inpatient population consecutive sample (single service) n=15 Age 9–48 (mean 28.5) Acquired Brain Injury (no more than 2 years post-injury) USA	Group 1: (Casting intervention month 1; standard care month 2) Circular elbow or wrist casts or both applied (5 to 10°off max ROM) Details of casting application given. Applied for 5–7 days for 1/12	Group 2: (Standard care month 1; casting intervention month 2) Standard care included: passive & active ROM, prolonged stretch, splinting (including bi-valved casts worn intermittently), neurophysiological techniques (e.g. neurodevelopmental treatment, proprioceptive neuromuscular facilitation) & relaxation techniques	ROM (goniometer) Joint angle of catch on fast muscle stretch Functional tasks	Casting showed a significant reduction on spasticity (p=0.001) and PROM (p=0.014) Results on function were non-significant (p=0.347)	Grade C – low Downgraded from Grade A due to limitations: • Intervention and standard care very closely related in this study • Limited application, with no overall significant difference shown in all areas, but spasticity • May give indication for future evaluation but cannot dictate practice • Conclusion states casting more effective than traditional methods, which is overstating the findings in the paper.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if applicable)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Jung et al (2011)	Randomised controlled trial Aim: To evaluate the effect of a stretching device on hand spasticity in chronic hemiparetic stroke patients Chronic hemiplegic stroke patients recruited from stroke services Rigorous exclusion criteria applied. Stroke – min 6 months post n=21 (Expt 8M, 2F aged 45.6 ± 8.1; control 7M, 4F aged 47.5 ± 13.3) Republic of Korea	n=10 Stretching device: resting hand splint, finger stretcher, and frame. The stretching state was maintained for 30 seconds and relaxed for the next 30 seconds repeated for 20 minutes (one session) The stretching program was practiced 2 sessions per day and 6 days/ week for 3 weeks	n=11 No intervention	Modified Ashworth scale (MAS)	Intervention group: the average of mean MAS score between Pre-1 and Pre-2 was not significant ($p>0.05$). Significant improvement post intervention ($p<0.001$) using One-way repeated measures ANOVA test for evaluation of effect across all time-points.	Grade C – low Downgraded from Grade A due to limitations: • Comparison between intervention and control groups not presented • Small sample size • No details of randomisation or allocation • Outcome assessor not blinded • Clinical difference not evaluated • No significant difference likely in this study • Intervention unlikely to be practical in practice.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if applicable)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Lai et al (2008)	Controlled cross over trial Aim: to examine the efficacy of low load, prolonged duration stretch with a dynamic splint for ankle contracture Recruited volunteer sample n=50 people ≥ 1 year post stroke (n=30) or TBI (n=20) All had existing PF contracture Age = not provided Outpatient facilities USA	Custom fit Dynamic ankle DF (AFO) splint (dynasplint) Standard protocol (including heat, education, joint mobilisations, self-stretch at home) 2x per week for 6/12 Cross over expt group (n=35, 21 stroke, 14 TBI) Dose (splint) = 6–8 hrs overnight for 12/52 (i.e. additional 42 to 56 hours per week end ROM therap) Diary kept of wearing times Tension increased as DF improved, (based on tolerance)	'Non- expt group' (n=10, 5 stroke, 5 TBI) Standard protocol (including heat, education, joint mobilisations, self-stretch at home) 2 × per week for 6/12	PROM (ankle DF) – goniometer Measured at enrolment, 3 (cross over) and 6 months Measured by same prescribing & treating therapist	n=45 (5 dropped out due to non-compliance) Statistically sign change in PROM in expt cross-refer over group p=0.0007, f=4.795, between cross-over groups NS Expt Stroke Pre –7.4 ± 29.1 Post 24.2 ± 23.9 TBI Pre –14.1 ± 31.8 Post 11.5 ± 29.7 Control Pre –7.9 ± 28.7 Post –10.1 ± 29.9 No adverse reactions reported	Grade C – low Risk of bias high. Study limitations include: • Participants selected for cross-over based on 'physicians prescription of the AFD' • Outcome assessor not blinded • Incomplete data not accounted for (5 drop outs) • Expt cross over group showed greater improvement in DF PROM • Possible purposive selection of intervention group with risk of bias • Authors suggest using AFD allows therapists to focus on higher rehab challenges including motor skill acquisition.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if applicable)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Lannin et al (2003)	Randomised controlled trial Aim: To valuate the effectiveness of splinting the hand in the functional position after brain impairment to reduce loss of ROM n=28 acquired brain injury (single stroke or TBI) within 6 months of injury (n=17 expt group 5M, 6F; 65 ± 16.4; n=11 control 8M, 9F, 68 ± 7.4) People with active wrist ext excluded Not known if pre-existing contractures Australia – rehabilitation centre	Splint applied in functional position 10–30° ext at wrist plus usual care (including UL use = 30 mins/day 5 × 7 week and UL stretches = 2 × 30 mins 5/7) Dose – 12 hours overnight (max)	Usual care including UL use = 30 mins/day 5 × 7 week and UL stretches = 2 × 30 mins 5/7)	Baseline, end of study 4/52, and 38 day post-intervention (follow up) Primary – length of wrist and finger flexors (torques controlled wrist ext) Secondary – hand and UL function (motor assessment scale) Pain – VAS	Participants in both groups similar at baseline 5° MCID a priori (p≤0.05) Effects of splinting statistically non-significant mean 1° after intervention (95%CI, –3.7 to 6.1°) At f/u mean 2° (95%CI, –7.2 to 3.2°) – favoured control group No adverse events reported	Grade B – moderate Downgraded from Grade A due to limitations: Overall a well-conducted study but key co-intervention not addressed • Not possible to blind therapist and patients • Blinded assessment of outcome measures • Valid outcome measures Splinting in functional position (i.e. not at end range) does not produce beneficial effects in adults receiving UL training & stretches.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if applicable)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Lannin et al (2007a)	Multicentre randomised controlled trial Aim: To evaluate the effects of splinting on wrist contracture after stroke n=62 Control = n=21 (9M, 12 F; 75.4 yrs ± 11.00), Neutral = n=20 (9M, 11F; 70.3 yrs ± 12.6), extended (n=21, 12M, 9F; 68.7yrs ± 12.1) Within 8 weeks of stroke, 18 +, with no active wrist extension Sydney Australia – 9 inpatient stroke and rehabilitation units	Overnight wrist splint in either neutral or extended wrist (> 45°) position plus usual care Dose = 28 night, up to 12 hours/night Total maximum of 336 hours No stretches of wrist/ long finger flexors allowed Max 10 mins isolated wrist & finger extension practice each day	Usual care No stretches of wrist/ long finger flexors allowed 10 mins isolated wrist & finger extension practice each day.	Baseline, post (4/52), 12–24 hours post-splint removal, f/u 6 weeks Primary: Extensibility wrist & finger flexors – standardised torque Wrist extension – lateral photographs Secondary: UL function – Motor assessment scale Spasticity – Tardieu Disability – DASH	5° MCID a priori Neutral wrist splint increased wrist ext mean 1.4° (95%CI, –5.4 to 8.2°) Wrist in extension reduced wrist ext by mean 1.3° (95% CI, –4.9 to 2.4°) On average lost 17° wrist range of movement at end of 6/52 study	Grade A – high Well conducted study within study limitations • Not possible to blind therapist and patients • Blinded assessment of outcome measures, • Valid outcome measures Recommends routine practice of hand splinting to prevent contracture to be discouraged in people with stroke.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if applicable)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Lehmkuhl et al (1990)	Retrospective cohort analysis of clinical records (with follow up) Aim: To evaluate the effect of multimodality treatment of joint contractures in patients with severe brain injury Based in a single rehabilitation unit. n=25 (16M, 9F) Age 3–54, mean 25 years Approx 6/12 between injury & first cast Acquired Brain Injury USA	Serial casts applied at elbow, knee and ankle. n=21 elbow casts (av 12/7, changed every 3/7) n=7 knees (av 15/7, cast changed every 3/7 n=14 ankles (av 22/7, changed 5–7/7)	n/a	Range of movement	Significant post intervention improvement in ROM at 3 joints (& mostly maintained). Average pre –50.0 ± 26.00, post –23.3 ± 16.8 ($p<0.001$) Elbow ext most successful then kn next. Elbows & knees respond quicker than ankles Used orthotic device to maintain gains Adverse events: 1 case of skin breakdown 1 cut when removing cast	Grade D – very low • Evident risk of bias due to lack of control and retrospective nature of study • Indication of the benefit of serial casts in improving range of movement in this patient group • Raises useful questions for future evaluation in a systematic manner.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if applicable)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Leung et al (2013	A multi-centre randomised trial (RT) with concealed allocation Aim: To evaluate the effectiveness of electrical stimulation and hand splinting for contracture management after TBI n=36 Stroke (n=31) or TBI (n=5) Expt n=18, age 66 (57–75) Cont n=18, age 48 (34–62) Time post stroke average 55 days (32–94) Australia	4-week programme of intervention for both groups Custom-made hand splints for 12 hours per day for between 5 & 7 days per week The experimental group received electrical stimulation to the wrist and finger extensor muscles for 1 hour a day over 4 weeks	Splint only	Assessor blinding Primary: passive wrist extension measured with 3 Nm torque & fingers in ext. Secondary: passive wrist ext, wrist & finger ext strength (dynamometer), wrist flexor spasticity (tardieu scale), motor control of the hand (Motor Ax Scale), & Global Perceived Effect and perception of treatment credibility	ITT analysis At 4/52 mean between-group difference for passive wrist ext was 7 degrees (–2 to 15) & at 6/52, –3 degrees (–13 to 7) Secondary outcomes: statistically non-significant (or were of borderline statistical significance)	Grade A – high • Robustly conducted study, with appropriate statistical analysis and clear reporting • The authors concluded that a clear meaningful treatment effect was not produced, which is a robust conclusion given the remit of the study • However, significant changes were seen and intervention over longer duration (higher dose as recommended by the authors) may produce clinically meaningful effects.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if applicable)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Moseley (1993)	Prospective case series (before and after) Aim: To evaluate the effect of a regimen of casting and prolonged stretching on passive ankle dorsiflexion in traumatic head-injured adults n=19 (1F, 18M) (32 casted limbs, 16 R, 16 L) Average age 27.9 ± 10.2 years (range 16–50) LOC(days) 21.6 ± 11.3 (range 10–42) Median 90 days (36–648) post injury All had decreased passive DF (heel unable to reach ground) Australia – inpatient rehabilitation	Below knee cast + Stretching of calf muscles with knee extension (e.g. tilt table, long sitting (min 1 hr /day)) + motor training programme including sit to stand, standing, walking Dose = 7 days	No control group	Pre and post cast Passive DF – DF of ankle with known torque, photo of DF angle	Mean increase passive DF 10.4° ± 8.7 ($p<0.001$) n=28 increased DF between 3 and 36° n=3 decreased 1 & 8° n=1 no change	Grade C – low Overall a well-conducted clinical study but number of limitations, so risk of bias: • Small sample size • No control group unclear • Co-intervention variability in active task practice • Need RCTs to further assess efficacy of casting Findings suggest casting and prolonged stretching is effective for correcting calf muscle shortening.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if applicable)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Moseley et al (1997)	RCT cross over Aim: To evaluate the effect of casting combined with stretching on passive ankle dorsiflexion in adults with traumatic head injuries n=9 (1F, 8M), average age 29.1 ± 11.0. Time post injury 29–110 days (average 72.2 ± 27.1 All needed help to stand, decreased DF, unable to get heel to floor (corrective) Australia – brain injury units (inpatients)	Casting and stretching (1 hour/ day) Plus motor training programme (included walking, standing, sit to stand) Dose = 7 days (cast), 1 hour (stretch knee/ gastroc)	No casting or stretching Plus motor training programme (included walking, standing, sit to stand)	Before & after 0, 1 week, 2 weeks Passive DF – torque controlled + photograph of angle of ankle	Mean increase of 13.5° ± 9.3 DF with casting for 7 days plus and stretching for 1 hour/day Control group = 1.9° ± 10.2 (mean difference of 15.4° $p<0.05$) Adverse effects – 1 person withdrew due to discomfort of cast	Grade B – moderate Downgraded from grade A due to limitations Overall a well-conducted study but limitations, so risk of bias medium: • Small sample size • Unclear randomisation, allocation concealment etc • Co-intervention variability in active task practice • Need longer term follow up • Need RCTs to further assess efficacy of casting Findings suggest casting combined with stretch is effective in decreasing PF contractures in TBI.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if applicable)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Moseley et al (2008)	Pragmatic randomised controlled trial Aim: To evaluate the effectiveness of serial casting versus positioning for the treatment of elbow contractures in adults with traumatic brain injury n=26 (n=12 positioning, n=14 casting) Mean age 31.5 ± 11.2 23M, 3F Median 65 days (IQR 51–173) post injury Australia	Serial casting + individual therapy programme + exercises with the study arm for 15mins/day Dose: casts 2/52Casts changed at 1 week or earlier)	Positioning (stretch for 1 hour/ day, or 2 × 30 mins /weekday) (some 1 hr/day at w/e by family) + individual therapy programme + exercises with the study arm for 15mins/day	Baseline, post (2/52), post 2/52 plus 1 day, follow up 4/52. Primary: Elbow extension – standardised torque (spring balance), angle with digital inclinometer Secondary: Spasticity – modified Tardieu Max reach – sternum to table UL function – TEMPA Pain – VAS Perceived effect & difficulty of treatment – Likert scale	No clinically important differences between groups at baseline Serial casting = Post – increased 22° (95% CI, 13 to 31, p<0.001) Post + 1 day – increased 11° (95% CI, 0 to 21, p=0.052) F/U – increased 2° (95%CI, –13 to 17, p=0.782) Serial casting group had lower spasticity & better perceived treatment	Grade B – moderate. Downgraded from Grade A due to limitations: Generally well conducted study: • Allocation concealment • Blinded assessors • Co-intervention variability • Sequence generation not clear • Likely underpowered • Need RCTs to further assess efficacy of casting Initial change significant but lost at f/u 4/52. Change may be sustained if active elbow ext.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if applicable)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Pohl et al (2002)	A retrospective case-comparison study. Aim: To evaluate the effectiveness of serial casting in patients with severe cerebral spasticity (upper & lower extremities) Single centre n=105 ABI (n=67) and stroke (n=38) Average age 41.4 24F, 81M Germany	Serial casting of 172 joints (42 elbow, 41 wrist, 21 knee, 68 ankle joints), with cast-changing intervals of 5 to 7 days Comparison of cast changing intervals: **Group 1**: 5 to 7 days (92 joints, 56 patients) **Group 2**: 1 to 4 days (80 joints, 49 patients)	None	Percentage of normal maximum range of motion (ROM) at the completion of casting and 1 month after discontinuation, and the number of complications resulting from the casting procedure	Improved ROM immediately after serial casting and 1 month later in both groups (f=1469.5, p=0.001) No differences in ROM improvement between groups were observed (f=0.3, p=0.72) Complications in serial casting were found in 19.8% (n=34) of 172 casting procedures (29.3% in group 1 and in 8.8% in group 2; x=10.2, p=0.001) Discontinuation of treatment because of casting complications/ other reasons observed in 12.8% (n=22) of the entire sample, (18.5% in group 1 and in 6.3% in group 2; x=4.7 p=0.03)	Grade C – low • Casting effective in treatment of fixed contractures of upper & lower extremities caused by increased muscle tone of cerebral origin • Short changing intervals in serial casting provided improvements in ROM comparable with conventional changing intervals, and resulted in fewer complications • Retrospective case control following a change in practice • However, well-conducted study within limitations.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if applicable)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Pohl et al (2003)	Retrospective case-comparison study Aim: To compare the improvement and complication rates for serial casting in patients with shorter as opposed to longer illness duration, and in patients with lower as opposed to higher levels of consciousness (knees) Stroke & ABI Setting – single centre n=68 Average age 45.2 Germany	Primary Analysis: **Group A**, (n=24) Serial casting before 90 days **Group B**, (n=44) Serial casting at 90 days or more Secondary Analysis: **Group 1,** (n=25) Glasgow Coma Scale (GCS) score of less than 12 **Group 2**, (n=43) Glasgow Coma Scale (GCS) score of 12 or more Dose Median casting days = 8.25, casts changed median 2.5 days		Percentage of normal maximum range of motion (ROM) at the completion of casting and one month after discontinuation, and number of complications due to casting procedure. Functional Independence Measure (FIM) Modified Ashworth Scale Glasgow Coma Scale	No differences in ROM between duration groups (f=0.43, p=0.51) and GCS groups (f=1.3, p=0.26) were observed. Complications in serial casting were found in 25.0% (6/24) in group A, in 10.6%(7/44) in group B, in 24.5% (6/25) in group 1, and in 8.3% (3/43) in group 2	Grade C – low • Risk of bias due to retrospective nature • Suggests serial casting in patients with longer illness duration and higher levels of consciousness provides improvements in ROM comparable with earlier casting intervention in patients with more impaired consciousness, but results in a lower occurrence of complications • Relevant on HOW to practice.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if applicable)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Robinson et al (2008)	Randomised trial Aim: To evaluate the effectiveness of wearing a night splint and standing on a tilt table in preventing ankle contracture early after stroke n=30 (16 splint, 14 tilt table) 13F, 17M, average age 72 (SD 10), within 3/52 of stroke average 12 days post stroke (SD 5) Australia – in and outpatients	Night splint – ankle at plantargrade (off shelf or 'temporary custom made' Dose: Splint – 7/7 for 4/52 + inpatient rehab 5/7 early weight bearing and mobility or outpatient rehab – 1 or 2 × week NO other intervention aimed purely at DF	Tilt table – max DF with use of wedge Tilt table – 30 mins × 5/week for 4/52 + inpatient rehab 5/7 early weight bearing & mobility or outpatient rehab – 1 or 2 × week	Pre, post (4/52), follow up (6/52 later) Primary: Passive DF ankle – spring gauge known torque photo/surface markers Secondary: Stand up from chair 45cm high (item 4 of motor assessment scale)	Splint group DF = tilt table DF at 4/52 mean difference 1°, 95%CI –5 to 7 and 10/52 mean difference 3.5°, 95%CI –3 to 10 Compliance: Splint = 73% Tilt table = 87% Adverse events: pressure sores × 2 (splints not custom made) Pain/heat/tight × 5	Grade B – moderate Downgraded from Grade A due to limitations Well conducted trial, inherent biases as no control group • Power calculation • Co-intervention • Concealed allocation • Intention to treat analysis • Need RCTs to further assess as prevention of contracture may have been due to other factors When added to early rehabilitation, wearing a night splint is as effective as standing on a tilt table for the prevention of ankle contracture following stroke.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if applicable)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Shamila et al (2011)	Case comparison Aim: To evaluate the difference between upper extremity ROM and spasticity in stroke patients when comparing splinting and Botulinum toxin n=28 but n=18 completed the study. (Only reports completed data) > 1 year post-onset of stroke Toxin group – Average 48 years, 7 F, 2 M Splint group – average 52 years, 4 F, 5 M All max 3 on MAS Rehabilitation Units Tehran Iran	Volar/dorsal wrist/ hand splint – wrist in 10° ext., fingers 0° Dose = 2hrs/day + 6–8 hrs at night for 3/12 Or Botulinum toxin type A + all participants received occupational therapy × 3/week	No control group	Measures taken baseline, 1/12 & 3/12 PROM – goniometer MAS – spasticity FMA – function	n=18 Generally poor reporting. Appears similar results in both groups (most outcomes improved), all non significant between groups and ($p<0.05$) but different timescales i.e. toxin change noted earlier compared to slower change with splint	Grade D – very low Downgraded from Grade C due to limitations High risk of bias with many limitations in study design: • No control group • No details on outcome assessor, any blinding, reliability etc • Small sample size • High drop-out rate and no intention to treat analysis • Co-intervention • FMA is not a measure of function but impairment.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if applicable)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Singer et al (2003a)	Prospective repeated measures design Aim: To evaluate the effect of serial casting to correct equinovarus deformity of the ankle after acquired brain injury in adults n=16 (n=19 limbs, all had contracture or decreasing range & overactivity) 11M, 5 F, age 17 to 52 TBI, ICH, SAH – 3 to 10 months post injury All non-ambulatory Australia – inpatient	Below knee cast Predetermined discontinuation criteria = if no gains <5° of ankle PROM DF over 3 casts If PROM 10° with knee extension then resting splint made + individualised therapy programme	No control group	Baseline 5 measures pre casting, post initial cast, midpoint cast, after final cast (1 week post cast) Max ankle DF (knee ext & flexed) – goniometer Ease of transfer from bed to chair – transfer dependency scale (prior & 3/12 follow up)	Significantly improved ankle ROM: Knee flexed = mean 18° Knee extended = mean 16° p<0.0001 13 participants reduced need for transfer assistance p<0.0015	Grade C – low Well-carried out study within design limitations. • Small sample size • Inherent biases in study design (e.g. no control group, not randomised) • Co-intervention • Need longer term follow up Uncontrolled study that gives positive indication of casting for improving ankle DF in ABI.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if applicable)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Singer et al 2003b	Complicated design using pooled data Aim: To evaluate the extensibility, passive torque and stretch reflex responses in triceps surae muscles following serial casting to correct spastic equinovarus deformity Randomised controlled trial n=10 (n=5 originally enrolled in BTXA versus serial casting, n=5 serial casting only 3F, 7M Age 18–48 ABI – trauma, ICH, SAH or post removal of cerebral tumour 2–10 mths post injury Australia – rehabilitation unit	Serial casting + botulinum toxin A (final cast bivalve to use as splint) + individualised therapy programme Dose – mean casting period 5/52 (changed weekly)	Serial casting + individualised therapy programme	Pre, initial, mid, end, post (3/12 follow up) PROM ankle – knee extended & flexed – goniometer Passive resistive torque – ankle dynamometry Soleus stretch reflex onset – surface EMG	No difference in groups so data pooled Casting stopped in 1 as did not achieve gains after 3 casts Median improvements DF with knee flexed & extended 30° and 15° respectively ($p<0.001$) Passive resistive torque increased 4.3° $p<0.0001$ Maintained ROM at 6/12 in 8/9, used a back slab as required	Grade B – moderate Downgraded from Grade A due to limitations Largely well-carried out study within design limitations. Findings indicate casting increases DF • Small sample size • Randomisation and allocation concealment not possible • Co-intervention • Need longer term follow up • Need larger RCTs to further assess efficacy of casting.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if applicable)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Verplancke et al (2005)	A double-blind placebo–randomised controlled trial of three parallel treatments for lower limb spasticity Aim: To evaluate the effectiveness of botulinum toxin on lower limb spasticity following acute acquired severe brain injury Brain injury n=35 UK Median 10 days post-insult	Group 2: Lower leg casting plus injections with saline (group II) Group 3: Physical intervention as above, plus botulinum toxin into gastrocnemius and soleus muscles. Cast changed when 10° gain in DF	Group 1: Current (normal practice) physical treatment	Limit of ankle dorsiflexion at entry and exit after 12 weeks Glasgow Outcome Scale (GOS) Modified Ashworth Scale (MAS)	Significant improvements in the MAS scores in groups 2 and 3, but not in control (group 1) No difference between Groups 2 and 3 Cast and botulinum toxin patients also demonstrated a significant improvement in the GOS	Grade B – moderate Downgraded from Grade A due to limitations • Well-conducted study • Active intervention with casting prevents talipes equinovarus deformities in patients losing ankle movement • Casting alone was sufficient; the role of additional botulinum toxin needs further investigation, but is safe in these patients • Botulinum toxin may have a role to play in a minority not responding to casting alone • Cast & botulinum toxin patients demonstrated significant improvement in GOS, may suggest a confounding variable.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if applicable)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Yasar et al (2010)	Retrospective cohort no prospective selection criteria. Aim: To evaluate the efficacy of serial casting after botulinum toxin type A injection in improving equinovarus deformity in patients with chronic stroke Stroke n=10 Mean age 33.2 Mean 35 months ± 15.3 post insult Turkey	Serial casting consisted of short leg casts applied while in the prone position, with the knee flexed to 90 degrees and the ankle dorsiflexed to maximal attainable dorsiflexion while held in the neutral hind foot position. Plus botulinum toxin	None	Goniometry (ankle dorsiflexion with full knee extension) Physician Rating Scale (PRS) (knee, foot contact and change scores) Functional Independence Measurement (FIM) (gait scores)	Significant improvements in ROM were identified. Significant improvements also identified in FIM gait score (p=0.014) and PRS (p–0.014).	Grade D – very low Downgraded from Grade C due to limitations • Significant bias in study as retrospective nature & used change scores • Results indicate that serial casting may be an appropriate intervention following BoNT-A injection to prevent equinovarus deformity and improve the quality of walking in chronic stroke patients • Due to the degree of bias in this study, it should not be used to inform practice • Possibly inappropriate to use change scores in this analysis, but the primary p values were valid.

(b) Evidence tables of critically appraised systematic reviews

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if relevant)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Hellweg and Johannes (2008)	Systematic review of different aspects of physiotherapy intervention with a specific sub-section identified for casting and splinting 14 studies fulfilled inclusion criteria of review (n=2 Cochrane Reviews, n=2 systematic reviews n=8 RCTs, n=2 controlled trials) of which 5 = serial casting or splinting Acquired brain injury Switzerland	Serial casting or splinting (including botulinum toxin) Two systematic reviews (Watson 2001, Mortenson 2003) Three randomised controlled studies (Moseley 1997; n=9, Verplancke 2005; n=35, Lannin 2003; n=28)	Control groups used	Main measures in the relevant studies: Range of movement Modified Ashworth Scale	**(GRADE criteria used in this systematic review below)** **Recommendation grade B:** Improvement in PROM after serial casts or orthosis **Recommendation grade C:** Reduced spasticity after serial casts or orthosis **Recommendation grade A:** No *verifiable* clinical improvement after night splints in functional position	Grade B moderate Downgraded from Grade A due to limitations: • Review mostly well conducted • Methodological assessment of papers but not clear if more than one assessor • Limited summary of papers • Recommendations should be considered related to the review of specific studies in the current work • Final recommendation requires caveat that changes over long periods of time in specified patients may be possible (particularly related to casting) & needs testing.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if relevant)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Katalinic et al (2011)	Systematic review Aim: To determine the effects of stretch on contractures in people with, or at risk of, contractures (in people with neurological condition) (Cochrane review) with meta-analysis n=812 Varied neurological conditions (e.g. stroke, TBI etc) Australia	Joint stretch for treatment or prevention of contracture or standard care in most studies	Usual care or no intervention	1. Joint range of movement (degrees) (a) immediate effects (b) short-term effects (c) long-term effects 2. Quality of life 3. Pain	Results not statistically significant for any outcome evaluation area. Stretch does not have clinically important effects on joint mobility in people with, or at risk of, contractures if performed for less than seven months The effects of stretch performed for periods longer than seven months have not been investigated	GRADE A – high • This review is well conceived and conducted with robust evaluations applied • However, combination of prevention and reversal in the evaluation, different interventions and different doses may all have contributed to some confounding of the findings.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if relevant)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Katalinic et al (2010)	Systematic review (Cochrane review) with meta-analysis Aim: To determine the effects of stretch on contractures in people with, or at risk of, contractures n=1391 Variety of neurological and musculoskeletal conditions Australia	Joint stretch for treatment or prevention of contracture or standard care in most studies	Usual care or no intervention	1. Joint range of movement (degrees) (a) immediate effects (b) short-term effects (c) long-term effects 2. Quality of life 3. Pain	Results not statistically significant for any outcome evaluation area (see above)	Grade A – high • This review is well conceived and conducted with robust evaluations applied • However, combination of prevention and reversal in the evaluation, different interventions and different doses may all have contributed to some confounding of the findings.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if relevant)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Lannin and Herbert (2003)	Systematic review Aim: To investigate if hand splinting is effective for adults following stroke? n=19 studies, n=230 people. Most studies case series design (n=12; 63%), only 4 (21%) RCTs. Post-stroke adults Australia	Splinting for upper limb	Various	Function of hand Range of movement Tone Spasticity Oedema Pain	No significant difference in motor function or contracture formation (not all OMs commented upon)	Grade B – moderate Downgraded from Grade A due to limitations • Well-conducted review. More than 3 databases used, reference lists searched, methodological quality assessed with PEDro scale • Most studies poor methodological quality (mostly case series) • Insufficient evidence to support or refute the effectiveness of hand splinting for adults following stroke.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if relevant)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Lannin et al (2007b)	Systematic review Aim: A systematic review of upper extremity casting for children and adults with central nervous system motor disorders Adults and children – TBI, stroke and CP 11 paeds papers 1 paeds (n=153) & adults (n=184) 7 adult papers (2 = case studies) 3 RCTs, 4 systematic reviews, 9 studies lower level evidence Australia	Upper limb casting (casting defined as non-removal, external device made from plaster or casting tape	Various	Range of movement Tone Pain Oedema Spasticity in elbow, wrist or hand	High variability in casting protocols, little consistency or consensus in practice Identifies clinical indicators to cast in adults: soft tissue contracture, presence of spasticity, limitation in active range of movement, not being able to make a splint, prevention of contracture	Grade B – moderate Downgraded from Grade A due to limitations: Well-conducted systematic review, 2 reviewers, PEDro quality assessment, relevant databases searched, most papers low-quality evidence Insufficient evidence to either support or refute effectiveness of upper limb casting in the treatment of adults following TBI or stroke (and children with CP). No evidence of long-term benefits or adverse effects.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if relevant)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Mortenson and Eng (2003)	Systematic review (defined search strategy) Aim: To evaluate the effectiveness of the use of casts in the management of joint mobility and hypertonia following brain injury in adults. n=13 studies Traumatic Brain Injury (n=9 studies) Both TBI or Stroke (2 studies) TBI, Stroke, cerebral hypoxia, cerebral ischemia and other (1 study) Case report cerebral aneurysm Canada	Casts were applied to the ankle plantar flexors in 10 studies, the elbow flexors in 5 studies, the knee flexors in 3 studies, the wrist flexors in 2 studies and the combined ankle plantar flexors and knee flexors in 1 study Total wearing times varied from 1 to 4 days, with the exception of a mean of 102 days in the study by Kent et al Of the 10 studies on ankle casts, 4 studies had subjects bear weight (standing and walking) through the casts	Overall, the results were poor. Ten studies fulfilled 3 or less of modified Sackett's 7 criteria demonstrating the rigor of the study. Two Studies met 4 of the criteria, and 1 study met 5	Passive Range of Movement (PROM) Torque-controlled PROM Goniometry and electro goniometry 3-point scale of function Spasticity (a) joint angle (b) rapid movement Holden Functional Ambulation Classification H-reflex Four-point scale of spasticity (Modified Ashworth)	(GRADE criteria used in this systematic review below) Recommended Grade C: recommendation for use of casts in reducing spasticity after brain injury Recommended Grade B: Recommendation use of casts in improving PROM or preventing loss of PROM that results from complications of brain injury and subsequent spasticity Improvement in function cannot be supported Further evaluation with appropriate measurement methods needed	Grade B –moderate Downgraded from Grade A due to limitations: • Robust systematic review. It was not possible to perform meta-analysis • Low-level evidence in most papers included in review • Functional evaluation is needed, but will require a robust measure of function adhering to the ICF levels.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if relevant)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Tolfts and Stiller (1997)	Systematic narrative review of experimental designs (pre-Cochrane) Aim: To evaluate if patients with traumatic brain injury benefit from physiotherapy Medline & CINAHL and reference lists searched n=10 studies (3 × case studies), 123 participants with TBI (Serial casting – 6 papers; single applications Time post-injury 2 days to 13 months Authors Australian – various papers	Casting – below knee, long leg, elbow Splints Dose – 2 hours to 7.5 months	n/a	Range of movement Tone (plus others not relevant to guidelines)	Range increase from 10 to 93° from splinting/ casting No specific results on effect on tone	Grade C – low • No assessment of methodological quality • Small sample size • Inherent biases in individual study designs (e.g. no control group, not randomised) • Co-interventions • Need longer term follow up Review of evidence suggests casting or splinting may be effective in improving restricted range of movement after TBI Weaknesses in individual studies reduce confidence in the results.

Source	Design and participants (n) (including location and recruitment)	Intervention	Comparison (if relevant)	Outcome measure/s	Results	Risk of bias, quality, grade and comment (including limitations)
Tyson and Kent (2011)	Systematic review and meta-analysis Aim: To evaluate the effect of upper limb orthotics after stroke Randomised controlled trials only n=4, 126 participants Sample sizes 12 to 42, most based on power calculations Stroke & other non-progressive brain lesions Authors – UK, studies various	Splints/orthoses (not serial casting) – custom made thermoplastic splints applied to wrist, fingers and or thumb Dose: 12 hours overnight; 6 hours during the day; for 4–13 weeks	No treatment or usual care	Upper limb impairments Function Disability	Confidence intervals mixed, spanned zero & overall effect sizes not significant Disability: MD = 0.37 points; (95% CI, –0.19 to 0.93, p=0.2) Impairment: MD = 0.04° (95% CI, –5.21 to 5.30 p=0.99) Pain – 1 study found significant lower incidence of wrist pain with use of orthosis (1/15 vs 8/15, p=0.004)	Grade A – high Well-conducted study • All key databases searched, follow up of reference lists • Excluded non-english papers • Need longer-term follow up • Multiple studies by the same research team so conclusions should be treated with caution Findings suggest UL orthosis does not effect function, ROM at wrist, fingers or thumb, nor pain.

Appendix 8: Glossary and useful abbreviations

Abd	Abduction
ABI	Aquired brain injury
ACPIN	Association of Chartered Physiotherapists in Neurology
AFD	Ankle dorsiflexion dynasplint
AFO	Ankle foot orthosis
AMED	Allied and complementary medicine
ANOVA	Analysis of variance
ARAT	Action research arm test
ArmA	Arm activity measure
A-ROM	Active range of movement
AT	Achilles tendon
AVM	Arterio venous malformation
Ax	Assessment
BMJ	British medical journal
BoNT-A	Botulinum toxin type A
BTA	Botulinum toxin type A
BTX	Botulinum toxin
CI	Confidence interval
CK	Cherry Kilbride
Clin Rehabi	Clinical Rehabilitation
CMC	Carpo metacarpal joint
CNS	Central nervous system
COT	College of Occupational Therapists
COTSS-Neurological Practice	College of Occupational Therapists Specialist Section-Neurological Practice
CP	Cerebral palsy
CSP	Chartered Society of Physiotherapy
CVA	Cerebro vascular accident
DASH	Disabilities of the arm shoulder and hand outcome measure
DF	Dorsiflexion
DH	Department of Health
DIP	Distal interphalangeal joint
DORIS	Database of research in stroke
DS	Dorsal splint

DVT	Deep Vein Thrombosis
EMG	Electromyography
Expt	Experiment
Ext	Extension
F	Female
F/U	Follow up
FAC	Funtional ambulation categories
FES	Functional electrical stimulation
FIM	Functional independence measure
FMA	Fugl Meyer Assessment
GAS	Goal attainment scaling
Gastroc	Gastrocnemius muscle
GCS	Glasgow coma scale
GDG	Guideline Development Group
GOS	Glasgow outcome scale
GRADE	Grading of Recommendations Assessment, Development and Evaluation
GTO	Golgi Tendon Organ
HCPC	Health and Care Professions Council
HMIC	Health Management Information Consortium
Hrs	Hours
ICC	Intraclass correlation coefficient
ICF	*International Classification of Functioning, Disability and Health*
ICH	Intracerebral haemorrhage
incl	Including
IQR	Inter quartile range
ISWP	Intercollegiate Stroke Working Party
ITT	Intention to treat
JT	Joanne Tuckey
Jt	Joint
KH	Karen Hoffman
LL	Lower limb
LOC	Loss of consciousness
M	Male
MAS	Modified Ashworth Scale
MCID	Minimal clinical important difference
MCP	Metacarpal phalangeal joint
MDT	Multidisciplinary team
MN	Motor neurone
MS	Multiple sclerosis

MTS	Modified Tardiu Scale
MTU	Muscle tendon unit
n	Number
NICE	National Institute of Health and Care Excellence
NIHR	National Institute for Health Research
Nm	Newton metre
NS	No splint
OM	Outcome measure
Opp	Opposition
OT	Occupational therapist
PEDro	Physiotherapy evidence database
PF	Plantar flexion
PICO	Patient/population/problem, intervention, comparison and outcome
PROM	Passive range of movement
PROM	Patient reported outcome measure
PRS	Physical rating scale
PT	Physiotherapist
RCP	Royal College of Physicians
RCTs	Randomised controlled trials
RMI	Rivermead Mobility Index
ROM	Range of movement
RTPM	Resistance to passive movement
SAH	Sub arachnoid haemhorrage
SCED	Single case experimental design
SCI	Spinal cord injury
SD	Standard deviation
SLT	Speech and Language Therapist
TB	Tess Baird
TBI	Traumatic brain injury
TEMPA	Test d'Evaluation de la performance des Membres Superieurs des Personnes Agees
UL	Upper limb
UMNS	Upper motor neurone syndrome
VAS	Visual analogue scale
VS	Volar splint
WHO	World Health Organization

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Splinting for the prevention and correction of contractures in adults with neurological dysfunction

Practice guideline for occupational therapists and physiotherapists

This practice guideline provides specific recommendations to support clinical practice and decision-making in splinting when used as an intervention for adults with neurological conditions who have, or are at risk of, contractures.

While primarily a tool to support occupational therapists and physiotherapists in their practice, this document will also be of interest to students, researchers, service users, commissioners and any others who wish to gain insight into the roles and responsibilities of clinicians in this area.

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