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Upper Limb Casting Application Post-Botulinum Toxin Injection for Elbow Spasticity: A Guided Casting Protocol

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Abstract

Casting is an effective adjunctive treatment which increases the effects of botulinum toxin on patients with spasticity. The evidence for casting as an adjunctive therapy post-botulinum toxin has been well documented in the literature. However, standardized casting protocols are lacking, with no published descriptions of upper limb casting application post-botulinum toxin injection for spasticity. In this paper we will describe our experience regarding the application of upper limb casting as an adjunctive therapy for elbow spasticity, detailing indications, contraindications and description of our protocol (materials required and technique).

Key words: Botulinum Toxin, Casting, Chemodenervation, Elbow, Spasticity, Upper Extremity

Introduction

Spasticity, a sensorimotor disorder characterized by intermittent or sustained involuntary muscle activation, is a common and potentially problematic consequence of upper motor neuron disorders[1,2]. The presence of spasticity is associated with worse health outcomes, reduced quality of life, and heightened economic burden in patients with chronic upper motor neuron conditions. With time, untreated spasticity can lead to the development of debilitating contractures[3,4]. Current literature demonstrates that in addition to lower extremity spasticity, upper extremity spasticity can also have negative consequences on gait[5,6]. There are various treatment approaches for spasticity, which differ based on the pattern of increased muscle tone, patient characteristics, and functional goals.

Botulinum toxin (BoNT) is an effective pharmacological treatment for focal muscle over-activity from spasticity[4,5]. Evidence has demonstrated that the use of adjunctive treatments following BoNT injection can improve outcomes of limb spasticity[6]. As well multimodal treatment approaches including casting can enhance spasticity treatment outcomes. A multimodal program for contracture management in patients with acquired brain injury (ABI), including BoNT, casting and motor training, has been found to be useful in improving joint range of motion[7]. Adjunctive casting may improve gait parameter outcomes following BoNT injection[8].

Casting, defined as a non-removable external device, provides total contact pressure that provides prolonged muscle-tendon stretch for contracture prevention and may reduce the afferent sensory input from cutaneous, muscle and joint receptors that contribute to spasticity. Casting may also contribute to a decreased alpha motor excitability which may also improve spasticity[9].

A large observational study found that BoNT has a clinically significant effect on elbow flexor spasticity, a common pattern seen in post-stroke patients[10]. Furthermore, a prospective study and a recent systematic review support that BoNT injection of the spastic upper limb muscles improves gait, which may be augmented by casting[4,11].

Casting of spastic upper and lower extremities, with or without BoNT, may improve gait function[12].

A 2020 systematic review of spasticity treatment using adjunctive casting with BoNT described positive results[8]. However, the study highlighted the paucity of research in management of upper extremity spasticity and the lack of consensus regarding casting protocols.

This article presents a detailed protocol for upper extremity casting for elbow flexor spasticity as an adjunctive therapy to BoNT, based on both current available evidence and expert opinion. Our objective is to develop and share standardized casting protocols for both clinical treatment and future research.

Methods

This casting protocol was designed by researchers from two academic Physical Medicine & Rehabilitation University settings (University of British Columbia, Canada and University of Lausanne, Switzerland). Two in person meetings between the research groups and 4 virtual meetings were conducted prior to designing the casting protocol. The authors of this paper have previously published studies, independently from each other, involving casting as adjunctive or multimodal therapy[8,12,13]. Muscle selection and dosage considerations of BoNT in the upper extremity were based on clinical examination, and provider expertise.

Patient selection

Appropriate patient selection is critical to properly identify those who would benefit from casting post-BoNT injection. Table I outlines group consensus of indication and contraindications for upper extremity casting. The application of serial casting post-BoNT requires interdisciplinary coordination between the physician and orthotist, in consultation with the patient. It is important that assessments are made by a physician experienced in spasticity treatment with a strong practical knowledge in Modified Ashworth (MAS) and Modified Tardieu Scale (MTS) to identify patients who can benefit from this treatment.

Patient ability to tolerate the casting treatment is a very important factor for compliance, thus we recommend careful consideration and adaptation of casting material. Farina et al. described a well-tolerated method of splinting over 4 months using a polyurethane-core mouldable system, made by two parts joined by zippers that were worn only at night, to increase patient comfort[14].

Baseline assessment and timeline

Spasticity assessment measures include MAS, MTS, passive and active range of motion at the elbow. Other outcome measures can be added depending on the patient's profile and goals, such as the Goal Attainment Scale (GAS)[15]. A digital video recording was also used for dynamic evaluation of goniometric parameters at the elbow. Casting is applied for one week and removed. A second assessment is done at this point to reassess the above measures. The casting may be repeated with the next round of BoNT injections if needed.

In our clinical setting, baseline assessments are conducted during the cast application appointment (from 10 to 30 days after BoNT injection). This window permits the toxin to achieve its clinically active phase while also permitting patients to select a timeframe where wearing a cast does not disrupt their activities of daily living (ADL's) or other scheduled activities. A 2022 survey, conducted in France, found that among participating spasticity experts, 76% agreed with this practice[16]. To improve patient outcomes, the implementation of a multi-modal program is recommended, which includes slow passive muscle stretching with a neurophysiotherapist after the BoNT injection and prior to casting to maximize the benefits of the treatment.

Determining casting angle

The casting angle is determined by goniometric assessment of the MTS V1 & V3 values recorded during the baseline outcome assessment (Supplementary Content 1A and B, http://links.lww.com/PHM/C363). There is currently no documented best practice approach to determine the desired angle for elbow casting. Thus, we propose the following method: Set the cast at 10 degrees less than the V1 maximum angle of ROM unless the patient perceives they will not be able to tolerate the position, or the patient begins to compensate. Compensation is identified by rotation or abduction of the shoulder where the elbow angle is no longer increasing with greater force applied.

Casting materials

Supplementary Content 2, http://links.lww.com/PHM/C364 shows the materials used in the authors' clinical setting but these materials can be supplemented with appropriate alternatives.

Padding

Padding, using Cellona® felt is used to avoid maceration and swelling (Figure 1A and B)[17]. First, a cotton stockinette is applied to the arm with an extra 10 cm of fabric at proximal and distal end (Figure 1C). Then, we add a shear reduction layer *(Softroll® (USA) or equivalent)* from proximal to distal end with 50% of overlap over the previous layer. The proximal end should be 1cm distal to the axillary crease and the distal end should end at the wrist crease (Figure 1D and F). Finally, additional padding is placed on bony prominences such as the olecranon, the epicondyles of the elbow, and the distal forearm ensuring that all edges are skived to provide tolerable pressure transitions (Figure 1E). Material for padding can include: Cellona® felt (Germany, Austria), foam, silicone, or equivalent. Heat, humidity, patient sensitivity, cost, clinician experience and availability of materials can influence decision making.

Cast application

Cast (BSN *Delta®-Lite (North Carolina, USA) or Lohmann & Rauscher Cellacast Plus® (Germany, Austria) or 3M Scotchcast Plus® (USA)*) is wrapped proximal to distal, leaving 2 cm of the shear reduction layer visible at the proximal end and 2 cm of both padding and shear reduction layer visible at the distal end. To prevent slipping and cast translation, a mild tension is recommended when the cast is applied (Figure 2A and B). A manual goniometer can be used to ensure that the angle for casting is appropriate while the cast is hardening (Figure 2C). The borders of padding must be accentuated at the elbow to prevent in-cast translation. Ensure that while hardening, the proximal edge of the cast must not flare in or out; the distal end can be flared out subtly to improve comfort (Figure 2D and E). After the cast hardens, the extra stockinette is folded back at each end of the cast back to the middle and wrapped with self-adhesive bandage (Figure 2F). We recommend synthetic casts with a fast polymerization time, since maintaining the correct position in patients with spasticity can be challenging and pressure points due to cast deformations should be avoided.

Depending on the level of spasticity and practitioner expertise, a casting assistant or a multi-stage casting process can improve cast comfort and accuracy. Multi-stage casting can be done in three steps focusing separately on the upper arm, elbow, and forearm independently. Following cast application, the patient should remain seated for 10 minutes to prevent cast distortion due to dynamic gait spasticity. Patients are to be provided with written and verbal instructions for care and wear along with an emergency removal explanation sheet should the cast need to be removed at a hospital if the clinician is unavailable.

Cast removal

Each cast is to be removed at 1 week post application. The cast is cut off in a bivalved manner with the patient seated comfortably (Supplementary Content 3A, http://links.lww.com/PHM/C365). Felt pen lines are to be applied to the medial and lateral sides of the cast to guide the cast saw during cutting. The line should only cross bony prominences where padding is applied underneath (Supplementary Content 3B and C, http://links.lww.com/PHM/C365). Spasticity may be provoked as the cast removal progresses, so it is recommended to start on the medial proximal side of the cast as the arm needs to be abducted to initiate a cut. Pulling the cast away from the arm while cutting the proximal and distal ends of the cast reduces the risk of contacting the skin. Setting a depth gauge on the cast saw will also help prevent over-cutting of the cast (Supplementary Content 3D, http://links.lww.com/PHM/C365). Following cast removal and limb inspection, patients remain sitting for 10 minutes before follow-up outcome measures are captured. As a follow-up to the casting protocol, patients are prescribed an orthosis and physiotherapy to focus on stretching the elbow flexors (18). We therefore recommend having the orthosis ready and the physiotherapy plan in place prior to casting.

Serial casting

Casts can be repeated if patient goals are not yet achieved and there has been no adverse results. If at the end of the second casting cycle, there remains functional patient goals and there is an ability to further stretch as per the above protocol, then additional casting cycles can be completed. We recommend taking one week off in between subsequent casting applications.

Outcome measures to be considered

In this protocol, the MAS, MTS, passive and active range of motion at the elbow, and the GAS are routinely utilized[15]. These measures can be repeated and followed at subsequent casting visits.

Discussion

To our knowledge, this is the first casting protocol for treating upper limb spasticity presented in the literature.

It is for this reason that we developed this upper extremity casting technique for clinical treatment and future research standardization (designing studies of casting as an adjunctive treatment to BoNT or multimodal studies including casting for spasticity management). This was based upon the clinical experience of two academic physicians who have treated used casting as a treatment modality in spasticity for 25 years, with multiple publications in this field[8,12,13].

This casting method is easy to learn, inexpensive, practical, and quick to apply in a variety of clinical settings. Furthermore, while our previous case series included only 10 subjects, the intervention was well-tolerated with no significant adverse effects[12]. If initial goals of treatment post BoNT are not met, then consideration for addition of casting post BoNT may be warranted as an adjunctive therapy or part of the multimodal therapy to help optimize goals[8,12,19,20].

Study limitations and future directions

This casting protocol was based on expert opinion from two academic centers, and various casting techniques have not been compared to determine optimal technique. Casting for elbow flexor spasticity may also have some limitations. For example, dressing of the patient can become more complicated while wearing the cast and may be difficult to tolerate in patients who have limited caregiver support.

In the future, evaluation of this casting method in children with upper limb spasticity would be valuable as few studies are available for upper limb paediatric application.

Data Availability Statement: Data sharing not applicable to this article as no datasets were generated or analyzed during the current study.

References

1. Lance JW. The control of muscle tone, reflexes and movement: Robert Wartenberg Lecture. Neurology 1980: 30:1303–1313.

2. Barnes M, Kocer S, Murie Fernandez M, Balcaitiene J, Fheodoroff K. An international survey of patients living with spasticity. Disabil Rehabil 2017; 39: 1428–1434.

3. Gracies JM. Pathophysiology of spastic paresis. I: Paresis and soft tissue changes. Muscle Nerve 2005; May;3: 535–551.

4. Esquenazi A, Mayer N, Garreta R. Influence of botulinum toxin type A treatment of elbow flexor spasticity on hemiparetic gait. Am J Phys Med Rehabil 2008; 87:305-310.

5. Simpson DM, Gracies JM, Graham HK, Miyasaki JM, Naumann M, Russman B, et al. Assessment: Botulinum neurotoxin for the treatment of spasticity (an evidence-based review): report of the Therapeutics and Technology Assessment Subcommittee of the American Academy of Neurology. Neurology 2008; 70: 1691-1698.

6. Mills PB, Finlayson H, Sudol M, O'Connor R. Systematic review of adjunct therapies to improve outcomes following botulinum toxin injection for treatment of limb spasticity. Clin Rehabil 2016; 30: 537–548.

7. Leung J, King C, Fereday S. Effectiveness of a programme comprising serial casting, botulinum toxin, splinting and motor training for contracture management: a randomized controlled trial. Clin Rehabil 2019; 33:1035–1044.

8. Farag J, Reebye R, Ganzert C, Mills P. Does casting after botulinum toxin injection improve outcomes in adults with limb spasticity? A systematic review. J Rehabil Med 2020; 52: 1–7.

9. Preissner KS. The effects of serial casting on spasticity: a literature review. Occup Ther Health Care 2002; 14: 99–106.

10. Turner-Stokes L, Fheodoroff K, Jacinto J, Maisonobe P, Zakine B. Upper limb international spasticity study: rationale and protocol for a large, international, multicentre prospective cohort study investigating management and goal attainment following treatment with botulinum toxin A in real-life clinical practice. BMJ Open 2013; 3. doi: 10.1136/bmjopen-2012-002230.

11. Cofré Lizama LE, Khan F, Galea MP. Beyond speed: Gait changes after botulinum toxin injections in chronic stroke survivors (a systematic review). Gait Posture 2019; 70: 389–396.

12. Jayawarden KS, Sandarage R, Farag J, Ganzert C, Winston P, Mills P, et al. Effect of treating elbow flexor spasticity with botulinum toxin injection and adjunctive casting on hemiparetic gait parameters: A prospective case series. J Rehabil Med 2020; 52: jrm00110.

13. Carda S, Invernizzi M, Baricich A, Cisari C. Casting, taping or stretching after botulinum toxin type A for spastic equinus foot: a single-blind randomized trial on adult stroke patients. Clin Rehabil 2011; 25: 1119–1127.

14. Farina S, Migliorini C, Bertolasi L, Casarotto M, Manganotti P, Fiaschi A, et al. Combined effects of botulinum toxin and casting treatments on lower limb spasticity after stroke. Funct Neurol 2008; 23: 87–91.

15. Turner-Stokes L. Goal attainment scaling (GAS) in rehabilitation: a practicalguide. Clinical rehabilitation 2009; 23: 362–370. https://doi.org/10.1177/0269215508101742

16. Allart E. Adjunct therapies after botulinum toxin injections in spastic adults: Systematic review and SOFMER recommendations. Ann Phys Rehabil Med 2022; 16.

17. Boyd AS, Benjamin HJ, Asplund C. Splints and casts: indications and methods. Am Fam Physician 2009; 80: 491–499.

18. Leung J, Stroud K. Long-Term Resolution of Severe Ankle Contractures Using Botulinum Toxin, Serial Casting, Splinting, and Motor Retraining. Physiother Can 2018; 70: 152–159.

19. Desloovere K, Molenaers G, Jonkers I, De Cat J, De Borre L, Nijs J, et al. A randomized study of combined botulinum toxin type A and casting in the ambulant child with cerebral palsy using objective outcome measures. Eur J Neurol 2001; 8: 75–87.

20. Ashford S, Turner-Stokes L. Spasticity in Adults: Management Using Botulinum Toxin. National guidelines. Royal College of Physicians of London (2018).

Figure Legend

Figure 1. Preparation and Padding prior to Cast Application

Description: Sequential application of Padding and Shear reduction layers prior to cast application to ensure comfort, pressure relief of bony prominences, and skin protection.

Figure 2. Cast Application and Manipulation to the Spastic Elbow

Description: Application of Casting materials and subsequent manipulation to optimize comfort and reduce risk of skin breakdown.

Table Legend

Table 1. Indications and Contraindications for Casting as an adjunctive treatment for BoNT in Elbow Flexor Spasticity.

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Figure 1

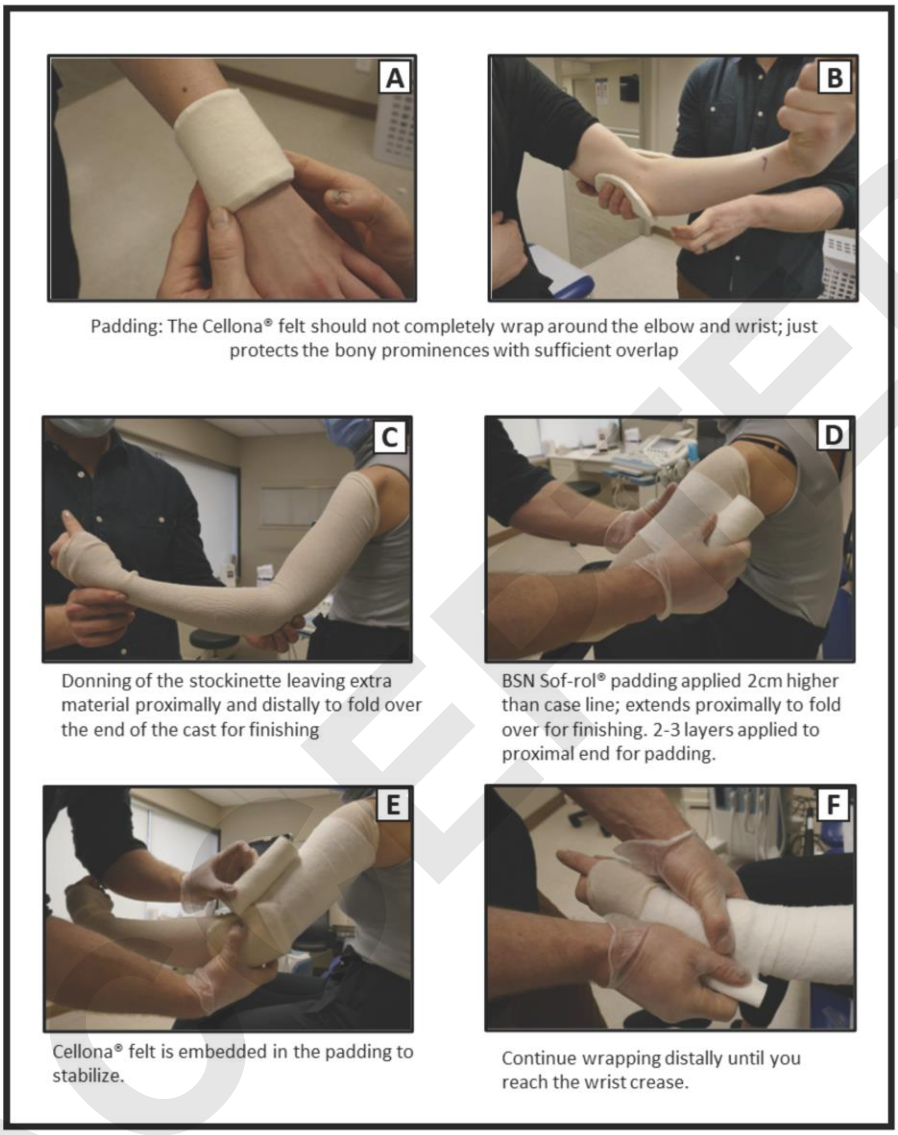
A
B
Padding: The Cellona® felt should not completely wrap around the elbow and wrist; just protects the bony prominences with sufficient overlap
C
D
Donning of the stockinette leaving extra material proximally and distally to fold over the end of the cast for finishing
BSN Sof-rol® padding applied 2cm higher than case line; extends proximally to fold over for finishing. 2-3 layers applied to proximal end for padding.
E
F
Cellona® felt is embedded in the padding to stabilize.
Continue wrapping distally until you reach the wrist crease.

Figure 2

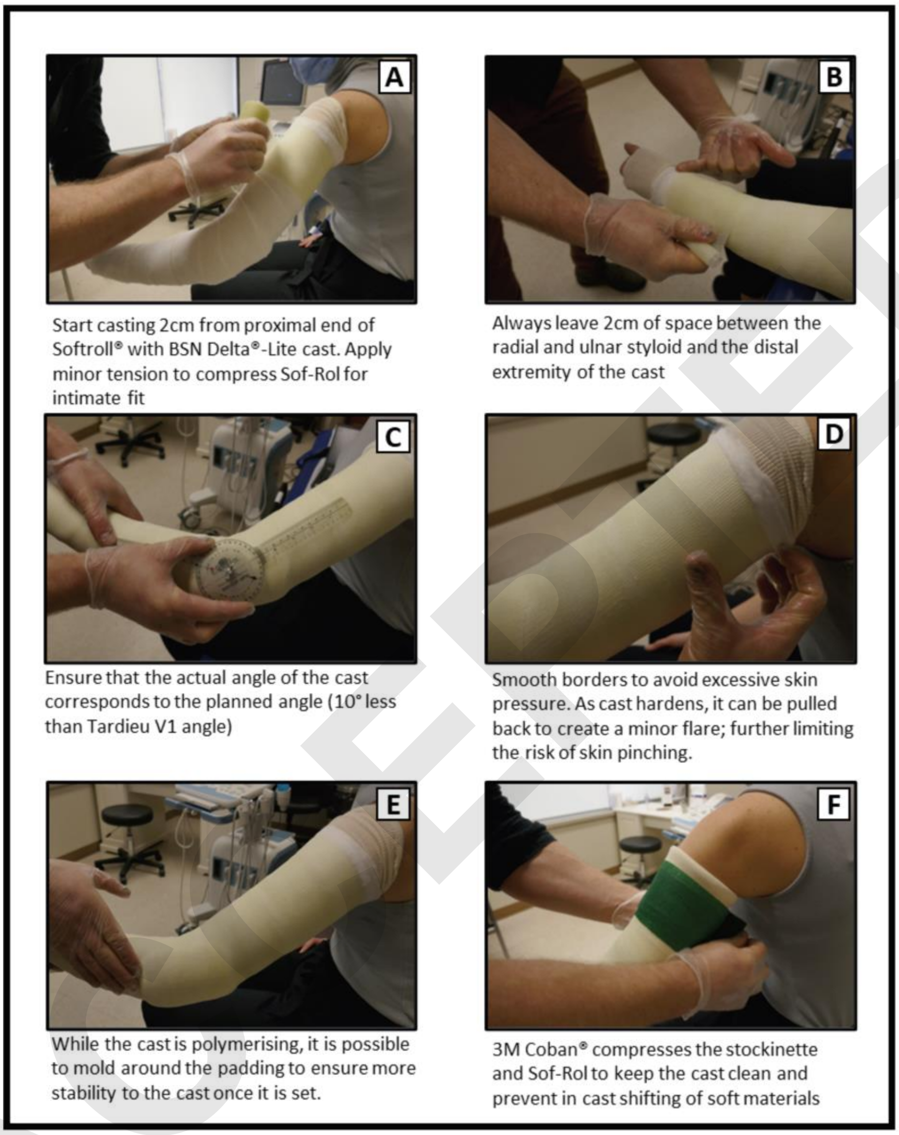
A
Start casting 2cm from proximal end of Softroll® with BSN Delta®-Lite cast. Apply minor tension to compress Sof-Rol for intimate fit
B
Always leave 2cm of space between the radial and ulnar styloid and the distal extremity of the cast
C
Ensure that the actual angle of the cast corresponds to the planned angle (10° less than Tardieu V1 angle)
D
Smooth borders to avoid excessive skin pressure. As cast hardens, it can be pulled back to create a minor flare; further limiting the risk of skin pinching.
E
While the cast is polymerising, it is possible to mold around the padding to ensure more stability to the cast once it is set.
F
3M Coban® compresses the stockinette and Sof-Rol to keep the cast clean and prevent in cast shifting of soft materials

Table I. Indications and Contraindications for Casting as an adjunctive treatment for BoNT in Elbow Flexor Spasticity.

Indications	Contraindications
• Spasticity following acquired brain injury, or as a result of other upper motor neuron disease • Elbow flexor spasticity with Modified Ashworth Scale (MAS) range of 1-3 • Minimum 10° discrepancy between the angle of maximum passive range of motion at slow speed (Tardieu V1) and the angle of catch or clonus at fast speed (Tardieu V3). • Adequate cognitive ability if patient living independently • Adequate social support in patient with cognitive disability	• Eroded skin surface • Significant edema • History of non-union fracture or recent fracture • Severe osteoporosis • Uncontrolled pain upper extremity (I.E arthritis) • Impaired circulation at the extremity to be casted • Recent (< 3 months) deep venous thrombosis at the upper extremity • Behavioural issues (agitation, patient's unable to engage in protocol, lack of caregiver support)