

Serial Casting for the Restoration of Soft-Tissue Extensibility in the Ankle and Foot



Scientific Rationale and
Clinical Management
Principles

By
Beverly Cusick, PT, MS, COF

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“The common secondary changes in the shape of the foot resulting from spasticity and contractures of the muscles require long-term planning of treatment, including physiotherapy, plaster casts, plastic orthoses, orthopedic shoes and, in some cases, operations, which should be delayed as long as possible during the growing phase. Premature lengthening of the Achilles tendon regularly results in iatrogenic foot deformities.”

– Jurg Baumann, 1986

Preface

This Third Edition, like the previous two, is designed to support, accompany, and expand on the content of the series-in-progress of instructional videotapes entitled: *Lower Extremity Deformity Management for Children and Adults: Serial Casting to Restore Soft-Tissue Extensibility at the Ankle and Foot* - the first of which is: **Cast Fabrication, Technique #1: The Flexcast Preparatory AFO®**. The combined contents are directed to clinicians who are involved in the management of foot and ankle deformity, and who work in the fields of orthopedics and neuromotor rehabilitation. The intended audience includes physical therapists, orthopedists, doctors of physical medicine and rehabilitation, orthotists, and physical therapy assistants and orthopedic technicians who assist in serial casting programs.

The application of a series of consecutive casts, with the purpose of gradually achieving functionally useful soft tissue extensibility and joint alignment, has been routine in clinical practice for reducing foot and ankle deformity in children and adults since the 1950's in England and South Africa, and since, in Australia, Switzerland, France, Canada, Russia, Taiwan, and the US. Serial casting offers clients with joint deformity of soft tissue origin - due to central nervous system dysfunction, and orthopedic and skin problems occurring at early infancy through adulthood - a relatively safe, nonsurgical method of regaining soft tissue extensibility and joint motion by gently implementing existing physiologic adaptation mechanisms. Though casting is often used in combination with Botulinum-A Toxin injections, Kay et al (2004) discovered that, in their hands, casting alone is a more effective - and evidently a safer option than the combined treatment. Their 12-months outcome study showed that the subjects who received their injections before casting demonstrated earlier recurrence of contracture and spasticity compared with those who underwent casting alone. Serial casting often follows a nerve block or a selective dorsal rhizotomy when the effect of these interventions on soft tissue extensibility is inadequate to optimize function.

This edition begins with:

- § A review of the physiologic characteristics of optimum muscle function
- § A nomenclature review - distinguishing spasticity from hypertonus and stiffness for the purpose of clarifying the assessment findings and the focus of intervention options
- § A discussion of optimum and pathomechanical ankle and foot function in gait
- § A review of adaptive muscle and associated tissue transformation in the presence of chronic, uninhibited, or poorly-moderated muscle activation and positional shortening
- § A discussion of the length-tension relationship and use-related changes as a clinically-observable and functionally significant set of observations.

A brief review of reliability studies of commonly-used clinical assessments of "spasticity" is followed by a detailed explanation of a highly standardized technique for manually measuring passive ankle dorsiflexion (DF) range of motion (ROM), embracing the properties of the length-tension curve by acknowledging and recording both **R1** and **R2** end ranges, and the quality of stiffness encountered on the passage between the two findings. These procedures are also demonstrated on the accompanying video, with a child with hemiplegic cerebral palsy (CP) serving as the demonstration volunteer.

The existing rationale for undertaking serial casting is undergoing a process of revision as new findings emerge from the muscle physiology laboratories. Researchers have refuted the long-held notion that small animal muscle and human muscle behave similarly – particularly with regard to sarcomere number change in response to use and immobilization. For this reason, I've trimmed down this section considerably, in favor of joining the reader in awaiting the evidence of the physiologic effects of serial casting on human muscle and soft tissues.

A variety of serial casting protocols, goals, techniques, materials, and outcomes has been reported and is again addressed, with attention in this edition to 2 programs or approaches that warrant our full attention for their effectiveness. These include the serial casting program designed and refined since the early 1990s by Mary Weck, PT and Moira Tobin-Wickes, PT, CO (now deceased and sorely missed) at Childrens Memorial Hospital in Chicago. Their highly effective program emphasizes neuromotor reeducation in the regulation of center of mass (COM) placement over the feet. Their casting program clientele include children with cerebral palsy (CP), idiopathic toe-walking (ITW) and talipes Equinovarus deformity. The second spotlight is on Elaine Owen's approach to 'tuning' and retuning the ankle angle in ankle-foot orthoses combined with the heel height of the accompanying footwear, in order to allow the user to practice optimum limb joint alignment over the course of several months to years while the AFOs and shoes undergo ankle and heel height alterations to accommodate improvements in the user's joint control and ROM improve.

I've stressed the importance of achieving age-appropriate, adequate, and normal ankle joint DFROM. Repeat casting is appropriate conservative management as long as it is successful, though a protracted course of training in COM placement can be expected to delay or defer those repeat castings. I join my experienced colleagues in observing that clients who rely on assistive devices – such as walkers or canes – to ambulate by loading their hands exhibit considerable difficulty maintaining gains made with serial casting, and require the greatest number of repeat cast applications.

A life-long condition warrants training in life-long management of its debilitating effects, as ultimately, the knowledgeable client is the best master of his own body. With a chronic condition such as CNS dysfunction, the capable client must be responsible for adopting an effective life-long regimen of body care, including soft tissue extensibility and strength maintenance.

Acknowledgments

It is not possible for a modality such as serial casting to evolve in isolation. I count the following people as contributors both to my clinical success with serial casting, and to the evolution of my techniques: Joan Mohr, PT, Eileen Donovan, MD, PM&R, Mary Smith, PT, Mary Weck PT, Jenni Dabelstein, Bphty, MHSc, Mary Cameron, Bphty, and John Russell, CP, O. I learn from them all continually and thankfully.

The authors of journal articles on casting and related research are equally important influences, and include the group of physicians from France who seem to be headed by the Tardieus; Wilson and Allen (1962) and TE Groen and Domisse (1964) in South Africa; Hayes and Burns (1970), Benke (1997), Webby et al (1992), and Cameron and Drummond (1998) in Australia; Booth, Montgomery and Doyle (1983) and Zablony (1987) in California.

Clinicians and researchers who use serial casting to prevent or reduce deformities have contributed their experiences and data to the literature in numbers too great to cite here, and so they are cited in the References and Readings section of this text. I consider most of them advocates for safe and effective deformity management, as they add weight to the argument – proposed by the esteemed, and also sorely missed Jurg Baumann (*p. 1*) – to defray if not at least delay surgical intervention until it is deemed to be absolutely necessary.

Shortland and Gough and colleagues, and Lieber and Friden and colleagues are currently making discoveries and raising questions that are fundamental to our evolving understanding of the physiologic effects of serial casting in humans. I appreciate their interest and efforts, and look forward to learning more from them all.

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Introduction

Serial casting is an advanced clinical skill that carries the risk of injury to the client. Any clinician who intends to use a new modality in patient care must demonstrate competency in both the academic and practical aspects of that intervention. Casting is no exception.

The Rehabilitation Institute of Chicago's Physical Therapy Department has compiled a comprehensive form, entitled ***Lower Extremity Casting Competency Check-Out***, each component of which must be approved and dated by a qualified examiner before the clinician is permitted to participate in serial casting interventions.¹ The check list spans an oral review of (known) casting rationale, documentation of results, contraindications, precautions, and care in the cast, with 2 practicum sections on the casting procedure and all related modifications, and on cast removal.

As the author of this manual and of the accompanying the cast fabrication videotape, I assume that every clinician who reviews these products has acquired a working knowledge of the anatomy, joint functions, biomechanics and pathomechanics of the foot, and of the closed kinematic chain as it relates to the foot and ankle. All clinicians who are involved with foot deformity management should acquire that knowledge base as an essential element - not only of casting competency, but also of competent general clinical practice.²

A casting series begins with a plan that includes appropriate goals, expected duration of the casting course based on the modulus of stiffness detected between R1 and R2 end ranges of passive ankle dorsiflexion (DF), monitoring, removal (who, how, and where), and follow-up care I advise clinicians with the appropriate fundamental training, who are new to casting, to find an experienced supervisor or mentor for their first few cast applications and removals.

Learning Objectives

On reading this entire monograph and viewing the accompanying videotape, the clinician is expected to be able to:

- § Relate ankle dorsiflexion (DF) range of motion (ROM) to ideal ankle and foot function in gait.
- § Discuss the changes in ankle DFROM "norms" from infancy through childhood, including the emergence of R end range.
- § Discuss the development of mastery over center of mass (COM) placement in gait.
- § Identify physiologic features and functional properties of healthy muscle and associated tissues.
- § Discuss the role of cutaneous receptors in the soles of the feet to the achievement and maintenance of erect posture, and relate this information to heel posting with the ankle set in plantarflexion.

¹ Rehabilitation Institute of Chicago (1999) *Procedure Manual: Casting Protocols for the Upper and Lower Extremities*. Gaithersburg, MD: Aspen Publishers. (Appendix D, page 185)

² I recommend the first 3 chapters of *Foot Orthoses and Other Forms of Conservative Foot Care* by Thomas C. Michaud (1997). Call or write for ordering information: Michaud Clinic, 517 Washington St., Newton, MA 02154, PH: (617) 969-2225.

- § Analyze the relationship between chronic anterior COM placement in gait and calf muscle contracture formation over time in kinesiologic perspective. Relate this phenomenon to the potential for recurrence of contracture after casting..
- § Distinguish between spasticity, hypertonus, stiffness, and poorly regulated muscle recruitment, and explain the clinical significance of these distinctions with regard to choosing optimum interventions.
- § Explain the normal physiology and functional significance of R1 (“first-catch”) end ROM, and compare that to the R2 end ROM encountered in assessing the extensibility of an excessively-recruited muscle group.
- § Explain the changes that occur in excessively recruited and shortened muscle and associated tissues as they pertain to the span of the passive length-tension curve between R1 and R2 end ROM.
- § Discuss the phenomenon of weakness in the shortened triceps surae muscle group.
- § Relate the scores obtained using the Modified Ashworth Scale and the Modified Tardieu Scale to the specific presence of spasticity, and to the process of soft issue transformation.
- § Discuss the clinical significance of acquiring meticulously standardized and functionally relevant passive ankle DFROM findings – recording both R1 and R2 end ranges - before, during, and after serial casting.
- § Determine whether a deformity meets the criteria for intervention with serial casts.
- § List 5 contraindications to serial casting for deformity reduction.
- § Compare Owen’s strategy - of “tuning” the combined system of ankle-foot orthosis and footwear to optimize joint alignment and heel-loading over time - to serial casting as it is presented in this text.
- § Discuss the advantages and disadvantages of incorporating a training regimen to improve COM placement in standing and gait into a serial casting and post-casting orthotic and practice program as suggested by Driscoll and Weck (2006).
- § Explain the rationale for instituting a lifelong range-maintenance regimen after restoring soft tissue extensibility.
- § Discuss the rationale for instituting a life-long strengthening program for the ankle and foot musculature – including both calf and anterior compartment muscles - after completing a casting course.

Elements of Optimum Ankle and Foot Function in Gait

Requisite Attributes for Normal Gait

Perry (1992) has postulated that the first four of these attributes are required for normal gait:

- § Stance phase stability
- § Clearance of the swing limb
- § Appropriate pre-positioning of the foot in terminal swing