Health Policy & Clinical Effectiveness Program

Evidence-Based Care Guideline

Serial Casting

Of the Lower Extremity

Minor revision to Development Process section was incorporated 08-31-2009

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Target Population

Inclusions: These guidelines are intended for use in patients 0-25 years of age with limitations in range of motion or those at risk of limitations in range of motion. These indications may include but are not limited to the following patient diagnoses:

- cerebral palsy (CP),
- traumatic brain injury (TBI),
- Duchenne Muscular Dystrophy (DMD),
- idiopathic toe walking (ITW),
- spasticity, and
- decreased range of motion.

Exclusions: These guidelines are not intended for use with patients with the following *(Cusick 1990 [O])*:

- skin surface not intact at the extremity to be casted
- uncontrolled hypertension *(Stoeckmann 2001 [S])*
- uncontrolled intracranial pressure
- autonomic storming, dysreflexia
- marked edema at the extremity to be casted
- history of non-union fracture or recent fracture at the extremity to be casted
- decreased bone density at the extremity to be casted
- bony restriction of joint, hard end feel at the extremity to be casted
- painful arthritis at the extremity to be casted
- need for limb access for monitoring vital signs and medication administration at the extremity to be casted
- impaired circulation at the extremity to be casted, including recent deep vein thrombosis *(Verplancke 2005 [B])*
- heterotopic ossification at the extremity to be casted
- longstanding or fixed contracture at the extremity to be casted *(Flett 1999 [B], Cottalorda 2000 [C])*

Target Users

Included but are not limited to:

- Caregivers including but not limited to:
  - Physical Therapists,
  - Occupational Therapists,
  - Physicians,
  - Nurses,
  - Rehabilitation Technicians,
  - Daycare personnel,
  - School personnel,
  - Recreational activity personnel,
  - Patients and families/caregivers.

Introduction

References in parentheses ( ) Evidence strengths in [ ] (See last page for definitions)

Decreased passive range of motion (PROM) and/or spasticity can be symptoms common to patients with cerebral palsy, traumatic brain injury, Duchenne muscular dystrophy, and idiopathic toe walking. Spasticity is typically caused by damage to the part of the brain (motor cortex) that controls voluntary movement. Patients that present with increased muscle tone and abnormal movement patterns are at a higher risk of muscle tightness *(Bertoti 1986 [B])*.

"Contractures and hypertonicity with associated limitations of passive and active range of motion (ROM) are impairments frequently addressed in the rehabilitation of individuals with neuromuscular, neurological, and some soft tissue disorders"*(Goga-Eppenstein 1999 [E])*. Spasticity is a muscular hypertonicity characterized by a velocity- dependent increased resistance to stretch, which is known to interfere with voluntary movement *(Umphred 1983 [O])*. Decreased range of motion at a joint results in abnormal movement and alignment at that joint with resultant decreased functional mobility.

Serial casting is a conservative technique that may be used to improve joint range in children with idiopathic toe-walking or spasticity *(Seyler 2008 [S])*. Serial casting in the cerebral palsy patient population has been shown to improve range of motion *(Brouwer 2000 [O])*.

Incidence of contracture in patients after traumatic brain injury is 84% with 76% occurring at the ankle *(Cusick 1990 [O])*. Serial casting is considered a favorable adjunct to physical therapy treatment to gain range of

motion in patients with traumatic brain injury, especially if completed in the acute phase *(Singer 2001 [S])*. Limited evidence has been found to support the efficacy of use of serial casting for patients with DMD *(Main 2007 [C])*. Several studies report improved range of motion and improved gait pattern with serial casting in patients with idiopathic toe walking *(Griffin 1977 [C], Katz 1984 [D], Brouwer 2000 [O])*.

Serial casting uses a series of casts to stretch soft tissue (i.e. muscles) for an extended period of time. This is done by applying a series of casts to gradually improve the child's range of motion. The goal of serial casting at the knee or ankle is to provide increased passive range of motion, prevent complications of deformity-producing positions, allow future use of orthotics when needed, and promote highest level of function and mobility. Following casting, the therapeutic program includes: home stretching, bivalved casts used as night splints for prolonged stretching, and ongoing physical therapy treatment for strengthening and functional mobility training.

Casting provides stability and prolonged stretch of a muscle which is immobilized in a lengthened position. When completed in a series using incrementally increasing angle of stretch, it has been found effective in improving range of motion by changing passive mechanical properties, reorganizing the structure of the connective tissue, and increasing number of sarcomeres of the muscle *(Mosely 1997 [B])*.

It has been reported that at least six hours of prolonged stretch is needed for effectiveness *(Tardieu 1987 [S])*. When stretching was as short as 2 hours per day, an increase in the contracture of the soleus muscle was observed in children with CP *(Tardieu 1988 [O])*. Serial casting may serve to reduce spasticity in muscles by decreasing the strength of abnormally strong tonic foot reflexes such as extensor thrust, positive support and tonic toe grasp in children with traumatic brain injuries *(Mosely 1993 [C])* and cerebral palsy *(Bertoti 1986 [B])*.

The challenges in serial casting include:

- varied individual response to casting
- patient's skin integrity
- patient's cognitive/communication ability to identify potential problems during casting
- parent/caregiver cognitive/communicative ability to identify potential problems during casting
- variation in materials used in reported literature
- variation in duration of casting and frequency of changes in reported literature
- variation in casting procedure in reported literature

Serial casting is sometimes used at the same time as botulinum toxin Type A (Botox®) injections. Botulinum toxin (Botox®) must be prescribed by a physician. Botox is often used as a pharmacological treatment for focal spasticity *(Verplancke 2005 [B])*. Botox can be injected directly into the muscle to block the release of Acetylcholine at the neuromuscular junction, which results in a reversible weakness/paralysis that has been shown to reduce spasticity and improve ambulatory status *(Flett 1999 [B])*. When used in combination with serial casting it has been shown to help maintain *(Verplancke 2005 [B])* and improve muscle length and passive joint motion *(Kay 2004 [B])*.

Without conservative interventions such as serial casting (with and without botulinum toxin Type A injections), more invasive procedures may be necessary *(Flett 1999 [B])*. One example may include tendo-Achilles lengthening with a surgical cost of $1,500.00 for one limb. This cost does not include operating room time, anesthesia cost, etc. Serial casting for one limb over four weeks costs less than one-half of the surgical costs alone *(LocalConsensus [E])*. Lengthening surgeries also have potential risks associated with them such as over lengthening, infection, scarring, and anesthesia *(Flett 1999 [B])*. Therefore, serial casting may be a cost effective and safe means of managing spasticity and decreased range of motion.

The objectives of this guideline are to:

- provide optimal skilled care to patients
- promote appropriate referrals
- improve functional outcomes
- decrease unwarranted variation in care
- improve patient/family satisfaction
- decrease/delay the need for invasive procedures *(Flett 1999 [B], LocalConsensus [E])*

Expected Outcomes

Expected outcomes of serial casting include:

- Increased passive range of motion of ankle dorsiflexion of at least 5-10 degrees *(LocalConsensus [E], Cusick 1990 [O])*;
- Increased passive range of motion of knee extension of at least 10 degrees *(LocalConsensus [E])*;
- Improved tolerance to passive manual stretching of affected extremity following each successive cast application *(LocalConsensus [E])*;

- If appropriate, increased ease of fit into ankle foot orthotics for positioning during rest, stance, or ambulation *(LocalConsensus [E])*.

Guideline Recommendations

Therapist Training

1. It is recommended that therapists providing casting care should have appropriate education, training and competence in casting and cast removal skills *(Goga-Eppenstein 1999 [E], Cusick 1990 [O])*.

Assessment and Diagnosis

Referral

2. It is recommended that the Division of Pediatric Rehabilitation be consulted when patients present with the following:
   - Decreased ROM in children who are diagnosed with CP, TBI, DMD, idiopathic toe walking, etc.
   - More than 5 degrees difference is noted between R1 and R2 *(Cusick 1990 [O])*.

     Note: R1 is the point of resistance to maximal velocity stretch and is the dynamic range of motion. R2 is the overall muscle length or muscle contracture and is slow passive range of motion *(Boyd 1999 [O])*.
   - Persistent hypertonicity/spasticity *(Goga-Eppenstein 1999 [E], Cusick 1990 [O])*
   - Extremity cannot be controlled with splinting alone *(LocalConsensus [E], Cusick 1990 [O])*
   - Tightness in feet interferes with comfortable wear or improved function with ankle foot orthosis (AFOs)/shoes. *(LocalConsensus [E], Cusick 1990 [O])*

Initial Evaluation

3. It is recommended that Pediatric Rehabilitation physician/referral source and casting therapist assess whether the patient is appropriate for serial casting, using the inclusion/exclusion criteria listed above. If patient meets exclusion criteria, casting therapist will contact referring physician to develop further plan of care*(LocalConsensus [E])*.

4. It is recommended that a Physical Therapy Evaluation be completed including the components named in Table 1. *(Goga-Eppenstein 1999 [E], LocalConsensus [E], Cusick 1990 [O])*

5. It is recommended that prior to serial casting, the treating therapist consider the following precautions and patient/family factors:
   - Allergies or prior skin reactions to casting materials
   - Decreased sensation
   - Poor communication
   - Confirmed fracture healing
   - Excessive sweating
   - Sensory Issues
   - Poor compliance with cast wear *(Goga-Eppenstein 1999 [E], LocalConsensus [E], Cusick 1990 [O])*

Table 1: Physical Therapy Evaluation

Patient Evaluation
History • Botulinum toxin injections sites and dates • Allergies/skin sensitivities • Past casting/orthotics history **Pain Screen** **Range of Motion** • Active • Passive (R1/R2) **Muscle Tone** **Strength** **Physical Findings (including skin condition)** **Posture** **Functional Skills** • Gross Motor Function Classification System (GMFCS), if appropriate • Observational Gait Scale (OGS), if appropriate
Interventions
Type of cast fabricated • Soft cast • Reinforced soft cast • Bivalved fiberglass
Patient/Family Education
• Purpose of serial casting and expected outcomes • Neurovascular checks • Emergent and non-emergent situations during serial casting • Cast doffing techniques for soft cast, if appropriate • Bivalved cast donning techniques, if appropriate • Activities to be addressed at home during serial casting, if appropriate • When to return for bivalved night splints, if appropriate
Plan and Recommendations
• Additional Physical Therapy services • Orthotics • Continue with serial casting until range of motion goals are achieved

6. It is recommended that a procedure to ensure that the correct extremity and joint are being casted be utilized.

   Note: The Universal Protocol from the Joint Commission on Accreditation of Hospital and Related Organizations includes conducting a pre-procedure verification process, marking the procedure site and performing a time-out prior to the start of casting to minimize the risk of casting the wrong extremity.

7. It is recommended that the patient/family be provided with written instructions detailing home management of the cast and follow-up therapy appointments.

Physical Therapy Patient/Family Education and Home Program Activities

Physical Therapy Patient/Family Education and Home Program Activities Following Initial Casting

8. It is recommended that the therapist provide Patient/Family Education in safe home management and cast care to include:
   - instructions for identifying emergency situations related to the cast that require immediate attention and may require removal of the cast
   - instructions for routine monitoring for pain, circulation, skin condition
   - instructions for monitoring condition of the cast
   - instructions for routine and emergency cast removal
   - instructions for contacting therapist to ask questions or report concerns

   (LocalConsensus [E]).

9. It is recommended that the patient/family carry out the following Home Program Activities throughout the casting program:
   - sleep position on side with pillow between the legs;
   - play position in tailor sitting, long sitting, or kneeling with towel support under cast;
   - walking activities with cast shoes on; hamstring stretches;
   - standing activities for strength and balance

   (LocalConsensus [E]).

10. It is recommended that ankle foot soft casts be routinely removed 24 hours prior to next casting treatment/application appointment to allow for bathing, stretching and weight bearing *(LocalConsensus [E])*.

11. It is recommended that the soft cast be removed immediately by parent via instructed method if the following occur:
    - Poor circulation in the casted extremity: weak pulse, nail bed does not quickly return to its original color after being squeezed gently, cold to the touch, swelling.
    - Evidence of or severe complaints of pain possibly indicating muscle spasms or skin breakdown, point tenderness
    - A cast that has become thoroughly saturated with water or fluids
    - Skin reaction such as rash, blisters, or abrasions
    - Unusual odor from cast

    (LocalConsensus [E]).

12. It is recommended that if the following non-emergent situations are noted, the patient/family will contact the casting therapist:
    - Refusal to bear weight on casted extremity
    - Cracks/dents in cast
    - Changes for the worse in sleeping/mood
    - Dampness
    - Slipping in cast
    - Redness/chaffing without significant swelling or skin breakdown
    - Increased complaints of itching
    - Knowledge of objects dropped into cast
    - Unusual odor from cast

    (LocalConsensus [E]).

Treatment Plan

13. It is recommended that at each consecutive casting session, the components named in Table 2 be assessed *(LocalConsensus [E], Cusick 1990 [O])*:

Table 2: Physical Therapy Consecutive Serial Casting Assessment

Patient Evaluation
Pain Screen **Range of Motion** • Active • Passive (R1/R2) **Muscle Tone** **Strength** **Physical Findings (including skin condition)** **Posture** **Functional Skills** • Gross Motor Function Classification System (GMFCS), if appropriate • Observational Gait Scale (OGS), if appropriate
Interventions
Type of cast fabricated • Soft cast • Reinforced soft cast • Bivalved fiberglass
Patient/Family Education
• Neurovascular checks • Emergent and non-emergent situations during serial casting • Cast doffing techniques for soft cast, if appropriate • Bivalved cast donning techniques, if appropriate • Activities to be addressed at home during serial casting, if appropriate • When to return for bivalved night splints, if appropriate
Plan and Recommendations
• Additional Physical Therapy services • Continue with serial casting until range of motion goals are achieved

14. It is recommended that successive removal, assessment and fabrication be repeated every 7 to10 days for 1 to 4 weeks. Additionally, casting may continue past the recommended 4 weeks if passive range of motion continues to improve *(Cottalorda 2000 [C], Brouwer 2000 [O])*.

    Note: In patients with Duchenne Muscular Dystrophy, the duration of casting is 10 to 11 days with cast changes every 3 days *(Main 2007 [C])*.

15. It is recommended that casting be repeated as above until range of motion goals are achieved *(LocalConsensus [E])*.

    Note: Normal range of motion goals are outlined in Table 3 *(Cusick 1990 [O], Kendall 1983 [O])*:

Table 3: Normal Range of Motion Goals

Normal Range of Motion Goals
Ankle dorsiflexion • <1 year: 45° • 1-4 years: 25° • 5-15 years: 10-20° • >15 years: 10-15° Knee extension • by 5 years: 0°

16. It is recommended that casting be discontinued prior to achieving range of motion goals at the discretion of the therapist discretion for the following possible reasons:
    - decreased skin integrity
    - allergic reaction
    - decreased tolerance
    - decreased safety
    - less than 5 degrees of gain in range of motion over two weeks.

    (LocalConsensus [E], Cusick 1990 [O])

Physical Therapy Patient/Parent Education and Home Program Activities at Completion of Serial Casting

17. It is recommended that the final cast be fabricated to be worn as a night splint *(LocalConsensus [E])*.

    Note 1: Ankle foot casts may also be worn during the day with cast shoes if daytime braces are not yet available. Stretching must be completed prior to donning. Bivalved ankle foot casts are applied with knee bent making sure that heel is down/back in bottom shell as far as possible. Skin check must be completed following doffing and 20 minutes thereafter to ensure that redness subsides *(LocalConsensus [E], Cusick 1990 [O])*

    Note 2: Bivalved knee extension casts are applied with knee as straight as possible and upper/lower leg down against bottom shell. The top shell must be applied, alignment checked and then straps tightened as much as possible without pinching *(LocalConsensus [E])*. Skin check must be completed following doffing and 20 minutes thereafter to ensure that redness subsides *(LocalConsensus [E], Cusick 1990 [O])*.

18. It is recommended that after final cast removal that the following activities be completed by patient/family, unless otherwise indicated:
    - nightly bivalved cast wear;
    - resuming ongoing physical therapy for strengthening and stretching;
    - pursuing short term physical therapy treatment for strengthening and stretching if it is not already in place;
    - heel cord and hamstring stretches;
    - balance and strength activities in standing

    (LocalConsensus [E]).

Discharge from Physical Therapy Casting Program

19. It is recommended that following final cast removal, the patient is discharged with a recommendation for short term physical therapy trial for strengthening and stretching *(LocalConsensus [E])*.

Follow up

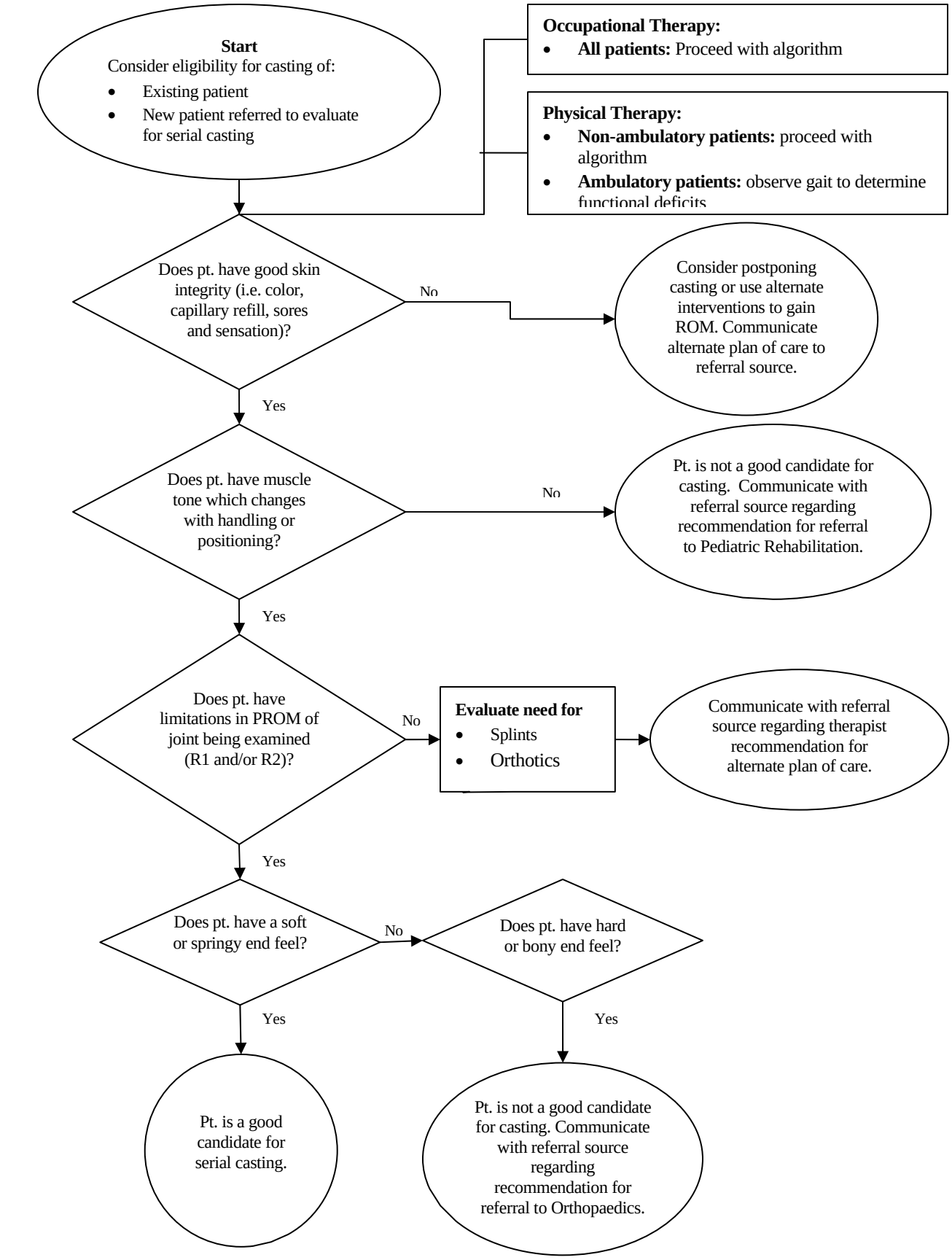
20. It is recommended that the patient/family contact the therapist if they identify one of the following problems within in 1-2 months after the serial casting program has been completed:
    - Poor fit of the bivalved cast
    - Pressure areas on skin
    - Cast integrity

    A new bivalved cast may need to be fabricated *(LocalConsensus [E])*.

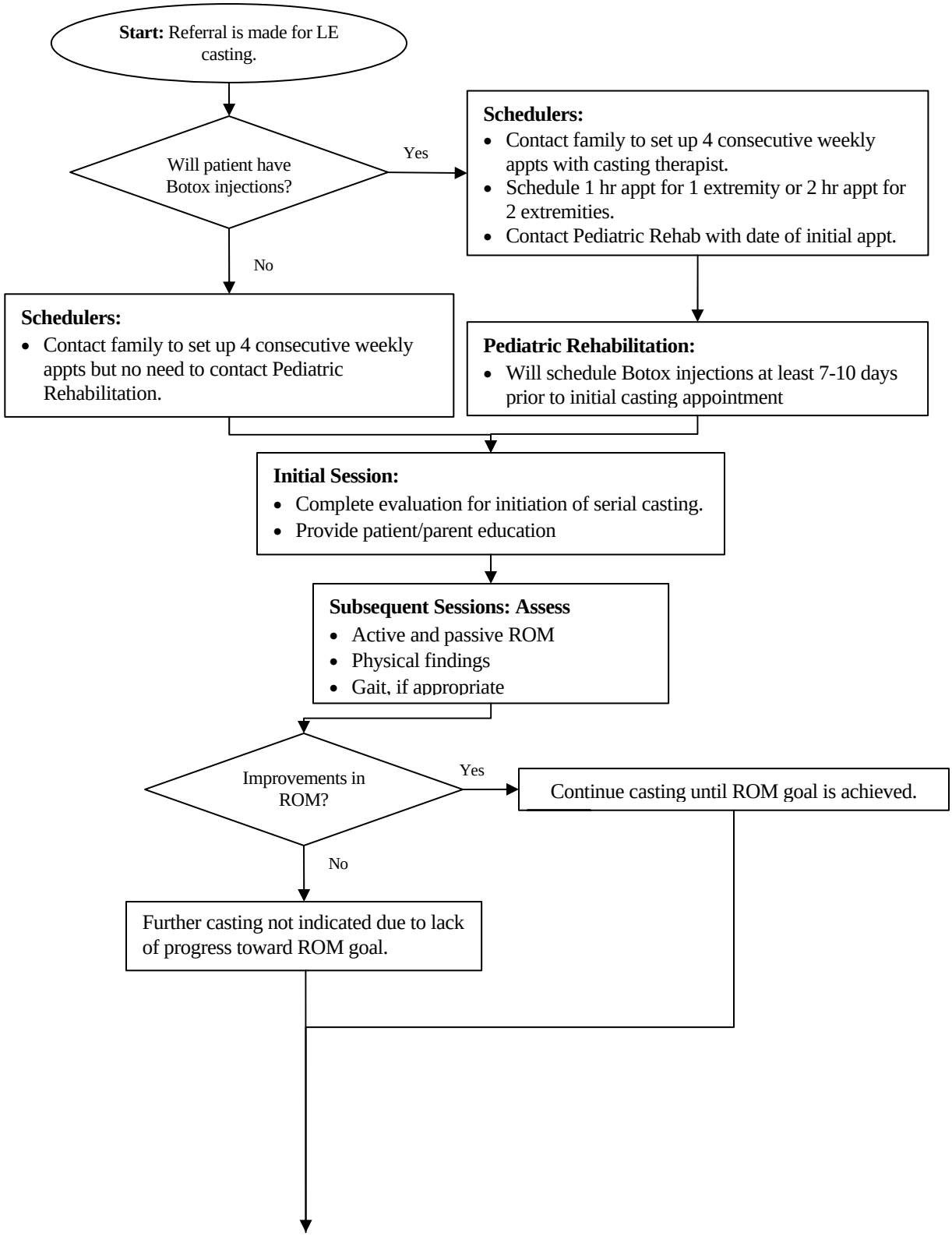
Future Research Agenda

1. In children with spasticity, how long do they maintain passive range of motion gains following serial casting both with and without night splinting?
2. Is the Observational Gait Scale sensitive enough to detect small increments of change in gait in the course of serial casting?
3. Do range-of-motion gains vary depending on the materials used for casting (i.e. soft cast versus fiberglass)?
4. Would the use of custom footboards inside the casts increase comfort or functional changes in gait (noted on the Observational Gait Scale) following serial casting?

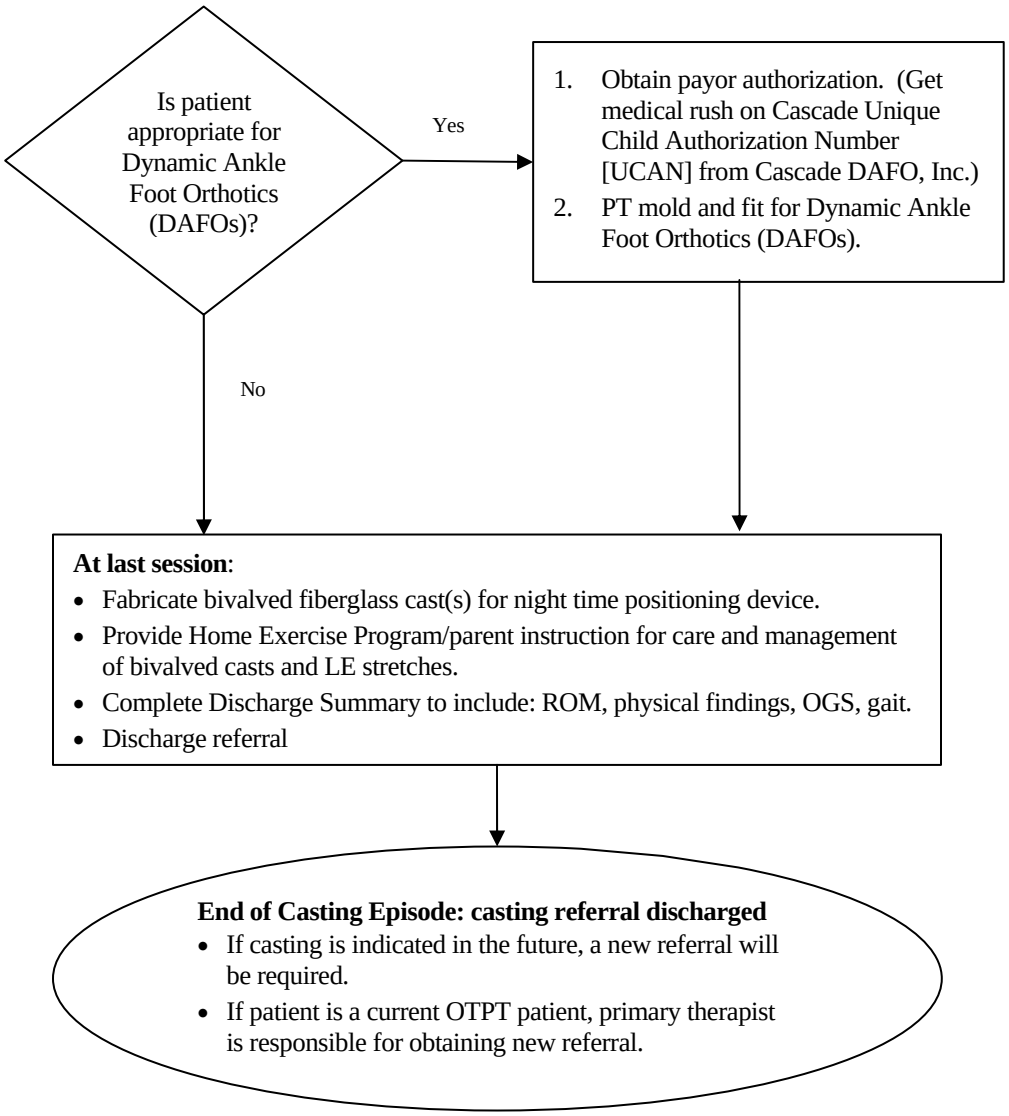
Algorithm for Patient Eligibility for Serial Casting



Algorithm for Serial or Bivalved Lower Extremity Casting Clinical Guideline for Casting Patients with Spasticity



Algorithm for Serial or Bivalved Lower Extremity Casting Clinical Guideline (continued)



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Development Process

The process by which this guideline was developed is documented in the Guideline Development Process Manual; a Team Binder maintains minutes and other relevant development materials. The recommendations contained in this guideline were formulated by an interdisciplinary working group which performed systematic and critical literature reviews, using the grading scale that follows, and examined current local clinical practices.

To select evidence for critical appraisal by the group for the update of this guideline, the Medline, EmBase and the Cochrane databases were searched for dates of January 1970 to February 2007 to generate an unrefined, "combined evidence" database using a search strategy focused on answering clinical questions relevant to serial casting and employing a combination of Boolean searching on human-indexed thesaurus terms (MeSH headings using an OVID Medline interface) and "natural language" searching on searching on human-indexed thesaurus terms (MeSH headings using an OVID Medline interface) and "natural language" searching on words in the title, abstract, and indexing terms. The citations were reduced by: eliminating duplicates, review articles, non-English articles, and adult articles. The resulting abstracts were reviewed by a methodologist to eliminate low quality and irrelevant citations. During the course of the guideline development, additional clinical questions were generated and subjected to the search process, and some relevant review articles were identified.

CCHMC Grading Scale			
M	Meta-analysis or Systematic Review	O	Other evidence
A	Randomized controlled trial: large sample	E	Expert opinion or consensus
B	Randomized controlled trial: small sample	F	Basic Laboratory Research
C	Prospective trial or large case series	L	Legal requirement
D	Retrospective analysis	Q	Decision analysis
S	Review article	X	No evidence

Tools to assist in the effective dissemination and implementation of the guideline may be available online at http://www.cincinnatichildrens.org/svc/alpha/h/health-policy/ev-based/default.htm . Experience with the implementation of earlier publications of this guideline has provided learnings which have been incorporated into this revision.

The Serial Casting Evidenced Based Practice Team will remain in place in the Division of Occupational Therapy and Physical Therapy. This team has been charged with continually exploring the literature for potential revisions to the guideline and to the Home Treatment Programs. At the three-year point the Team will reconvene to explore the continued validity of the guideline. This phase will be initiated at any point that Team finds evidence that indicates a critical change is needed. Feedback received for this version during the external review process (see AGREE [1] scores below) will be taken into full consideration at that time.

The guideline was externally appraised in two reviews using the AGREE instrument and the results by domain are:

- Scope and Purpose 89%
- Stakeholder Involvement 71%
- Rigor of Development 81%
- Clarity and Presentation 75%
- Applicability 56%
- Editorial Independence 100%

Recommendations have been formulated by a consensus process directed by best evidence, patient and family preference and clinical expertise. During formulation of these recommendations, the team members have remained cognizant of controversies and disagreements over the management of these patients. They have tried to resolve controversial issues by consensus where possible and, when not possible, to offer optional approaches to care in the form of information that includes best supporting evidence of efficacy for alternative choices.

[1] AGREE = Appraisal of Guidelines Research & Evaluation

The guideline has been reviewed and approved by clinical experts not involved in the development process, distributed to senior management, and other parties as appropriate to their intended purposes.

The guideline was developed without external funding. All Team Members and Clinical Effectiveness support staff listed have declared whether they have any conflict of interest and none were identified.

Copies of this Evidence-based Care Guideline (EBCG) and its any available implementation tools are available online and may be distributed by any organization for the global purpose of improving child health outcomes. Website address: http://www.cincinnatichildrens.org/svc/alpha/h/health-policy/ev-based/default.htm Examples of approved uses of the EBCG include the following:

- copies may be provided to anyone involved in the organization's process for developing and implementing evidence based care guidelines;
- hyperlinks to the CCHMC website may be placed on the organization's website;
- the EBCG may be adopted or adapted for use within the organization, provided that CCHMC receives appropriate attribution on all written or electronic documents; and
- copies may be provided to patients and the clinicians who manage their care.

Notification of CCHMC at HPCEInfo@cchmc.org for any EBCG, or its companion documents, adopted, adapted, implemented or hyperlinked by the organization is appreciated.

NOTE: These recommendations result from review of literature and practices current at the time of their formulations. This guideline does not preclude using care modalities proven efficacious in studies published subsequent to the current revision of this document. This document is not intended to impose standards of care preventing selective variances from the recommendations to meet the specific and unique requirements of individual patients. Adherence to this guideline is voluntary. The physician in light of the individual circumstances presented by the patient must make the ultimate judgment regarding the priority of any specific procedure.

For more information about this guideline, its supporting evidences and the guideline development process, contact the Division of Occupational Therapy and Physical Therapy Office at: 513-636-4651.

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Note: When using the electronic version of this document, "☜" refers to journal articles that have a hyperlink to the abstract.

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