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Update On Therapeutic Casting:

A Modern Clinical Pathway to Improve Outcomes

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Disclosure

- No relevant financial relationships exist

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Housekeeping

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Learning Objectives

Upon completion of this course, you will be able to:

- Select candidates for therapeutic casting using the ICF model.
- Differentiate contributing factors influencing restricted ROM at the ankle, including structural alignment, ground reaction forces, muscular pull, joint and soft tissue mobility, and directional susceptibility to movement.
- Apply a therapeutic cast with efficient body mechanics, selecting among casting techniques and materials based on patient presentation to direct forces to target structures and protect compromised tissues.
- Design casts to maximize therapeutic gait, using strategies to impact gait kinematics and kinetics with ground reaction force.

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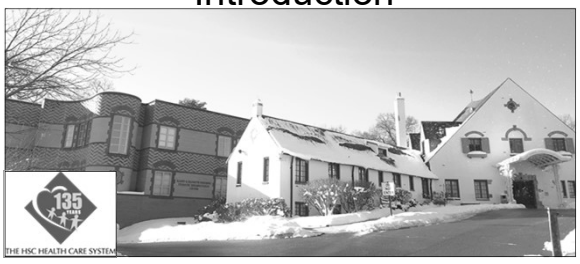
Introduction



Introduction

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2

Dorsiflexion (DF) Restriction Significance

2

- For those of us who stand or ambulate, the foot and ankle are the interface of our bodies with the contact surface.
- Altered function of this Body Structure can contribute significantly to Activity limitations and Participation restrictions.

Dorsiflexion Restriction: Causes

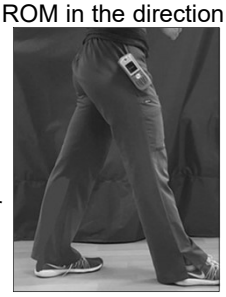
2

- DF is achieved through regular terminal stance
- Anyone lacking this movement experience is at risk for restricted DF

The ankle is biased to lose ROM in the direction of DF:

3

- Intrinsic resistance in posterior structures—which allows the system to store energy at terminal stance to power swing.



The ankle is biased to lose ROM in the direction of DF:

3

- The key arc of motion for gait is at end of the range in the direction of DF, not mid-range

The ankle is biased to lose ROM in the direction of DF:

3

- The resting position of the joint when non-weightbearing is in plantarflexion.

Anatomy

4

4

4

4

The ankle is a multi-joint complex, and in many movement systems, there is a movement that has become *relatively* more flexible than talocrural (TC) DF.

- In this case, ambulation does not give the movement experience necessary to improve range.

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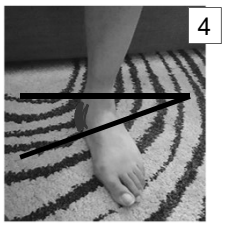

- Forces are directed to relatively more flexible structures and away from TC dorsiflexion.


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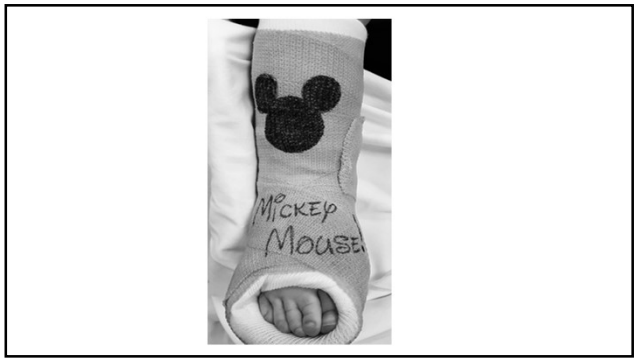
Mickey
Mouse

Dorsiflexion restriction: Casting

4

- Is casting an effective treatment for DF restriction?

Systematic Reviews

4

- Tustin and Patel: Physiotherapy Research International, 2017 (CP)
- Craig et al: Pediatric Physical Therapy, 2016 (CP)
- van Kuijk et al: J of Rehabilitation Medicine, 2014 (Toe walking)
- Novak 2013: Systematic review of interventions for children with cerebral palsy.

Systematic Reviews

5

- “Green light”
- Low grade evidence

Research Challenges

5

- Study design

Research Challenges

5

- Ethical considerations

Research Challenges: Heterogeneity

5

Bony structure based on genetics

↓ Tissue qualities based on genetics

↓

Driving pathophysiology – heterogeneous neurological insults ↓

Heterogeneity

6

Movement experience during development

↓ Weightbearing experience during development

↓

Structure based on experience during development

Heterogeneity

6

Structure based on experience during development ↓

Musculoskeletal pathophysiology (cumulative)

↓ Musculoskeletal pathophysiology (traumatic)

↓

Heterogeneity

6

Recent movement experience ↓

Recent weightbearing experience

↓

"10 year old with spastic diplegic cerebral palsy"

Heterogeneity

6

- Evidence is showing that muscle properties and stretch reflex response are highly variable and unpredictable, even among cohorted patients

Research Challenges: Methods

7

- ***The Parable of the Roast***

Research Challenges

7

Casting Method Variables

- Materials
- Position
- Number, training of clinicians
- Method of application (at each step in the process)
- Posting

Alternatives…

7

- Live with functional consequences
- Stretching
- Serial splinting
- Night-stretch splints
- Botox
- Surgery

Framework for Therapeutic Casting

8

Kinesiopathological model (Sahrmann)

8

Sahrmann S, Azevedo DC, Dillen LV. ***Diagnosis and treatment of movement system impairment syndromes.*** *Braz J Phys Ther. 2017 Nov - Dec;21(6):391-399. doi: 10.1016/j.bjpt.2017.08.001. Epub 2017 Sep 27. http://dx.doi.org/10.1016/j.bjpt.2017.08.001*

Kinesiopathological model (Sahrmann) 8

- Musculoskeletal, Nervous, Cardiopulmonary systems
- Biomechanics
- Repeated Movements
- Sustained Alignments
- Personal Characteristics

Kinesiopathological model (Sahrmann) 8

- Activity Demands
- Tissue Adaptations
- Path of Least Resistance
  - Relative stiffness of tissues
  - Intra and Inter joint relative flexibility
  - Motor learning
- Joint accessory Hypermobility
- Micro-trauma
- Macro-trauma

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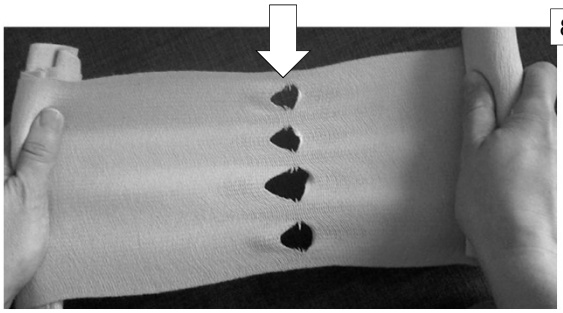

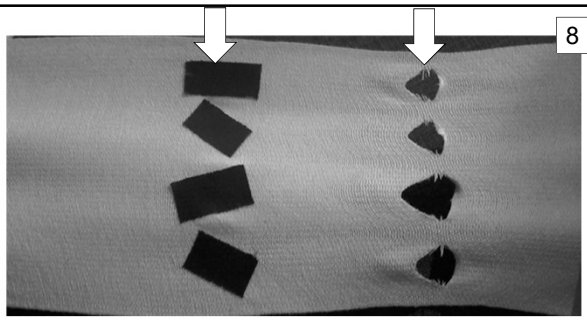

Framework for Therapeutic Casting

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Chronically restricted DF ROM is likely to result in:

- Pathoanatomical changes in tissues and joint structures

- Relative flexibility

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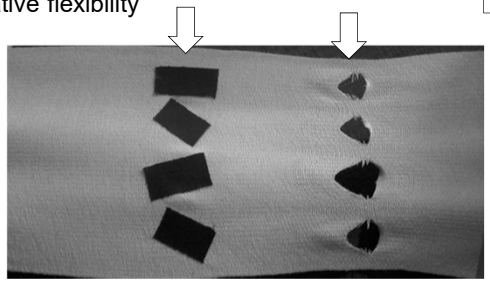

Framework for Therapeutic Casting

8

Chronically restricted DF ROM is likely to result in:

- Changes in relative flexibility of TC DF versus accessory motions

Framework for Therapeutic Casting

8

Chronically restricted DF ROM is likely to result in:

- Changes in muscle stiffness

Framework for Therapeutic Casting

8

Chronically restricted DF ROM is likely to result in:

- Changes in motor performance and learning

Framework for Therapeutic Casting

9

Ankle with chronic ROM restriction, altered motion, and weightbearing experience

What structures might be altered?

Muscle Structure and Function

9

Muscle Structure and Function

9

- Tonic muscle contraction

Muscle Structure and Function

9

- Change in length with change in # of sarcomeres
- Altered function and timing of contraction

Muscle Structure and Function

9

- Altered response to stretch (tissue level)

Muscle Structure

10

- Growing body of evidence that for patients with CP, stroke, and TBI, passive muscle properties are altered and are difficult to distinguish clinically from hyper-responsive stretch reflexes

Muscle Function

10

Altered neuromotor control
Altered accessory recruitment
Altered line of pull

Muscle Function

10

Altered line of pull

Framework for Therapeutic Casting

10

Connective tissues

- Altered ability to lengthen, fold, glide, compress, and expand

Framework for Therapeutic Casting

10

Framework for Therapeutic Casting

11

Joints

- Talocrural joint function
- Accessory joint function
- Relative intra- and inter- joint flexibility and stiffness

Framework for Therapeutic Castin
I. Differential Diagnosis

11

Using a kinesiopatholgoical, movement system approach

I. Differential Diagnosis

11

What is the anatomical structure?

I. Differential Diagnosis

12

Which structures and systems are preventing DF from occurring in the TC joint?

- Muscle and tendon
- Connective tissue
- Joint
- Relative flexibility
- Habitual patterns of movement

II. Preparatory Treatment

12

If connective tissue and joint function are contributing to DF limitations, they should be addressed coordination with casting

II. Preparatory Treatment

12

Joint mobilization (posterior talar glide) has been shown to increase DF range of motion for those with chronic ankle musculoskeletal impairment and patients with stroke.

- Lee 2017
- Kang 2015
- Kim 2018

III. Efficient, Effective treatment

13

Intentional use of the therapist's body in line with the target structures of the patient maximizes efficiency, clinical efficacy, and safety for both patient and therapist.

IV. Specificity of Cast Application

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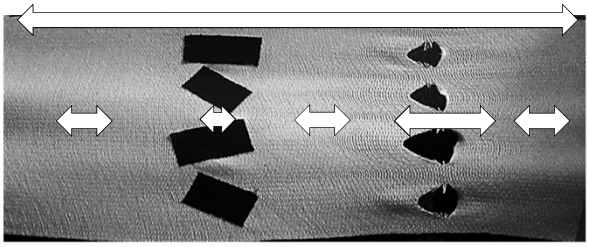
Forces from cast materials should be directed encourage mobility of target restricted structures to protect compromised structures

IV. Specificity of Cast Application

13



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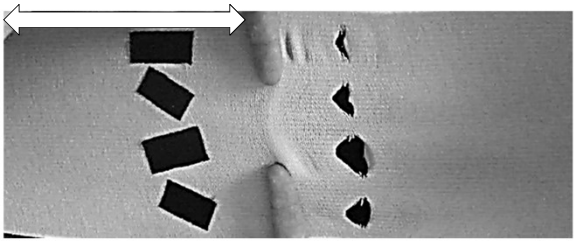
Segmental Application



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Targeting forces



13



Direction of Forces

Segmental Application

Directional wrapping

13


Multi-directional input v. static hold in linear direction

IV. Specificity of Cast Application

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- If the talus cannot be aligned to allow for DF within the TC joint, initial casts should address hindfoot alignment versus dorsiflexion

V. Aligning Casts for Weightbearing

14

Alignment of cast for weightbearing as a gait training intervention.

V. Aligning Casts for Weightbearing

14

VI. Reducing Patient Stress

15

VI. Reducing Patient Stress

15

- Stress hormones, both systemic and local, are detrimental to tissue healing
- Tonic muscle contraction can impede results
- Participation in a preparation program for procedures has been shown to significantly reduce the negative psychological sequelae experienced by children before and up to a month after procedures

VI. Reducing Patient Stress

15

Key elements of effective procedure preparation:

1. The provision of developmentally appropriate information
2. The encouragement of emotional expression
3. The formation of a trusting relationship with a health care professional

Child Life Counsel, 2008

15

- PASSIVE visual distraction, such as a video. This is preferred to a toy or game, as activity may increase tonic muscle contractions.
- Talk about, allow the patient to touch, and play with the casting materials like padding.
- Talk about each step of the process to allow them to anticipate.
- Allow them to "help," including donning gloves.
- Give choices (e.g. color, personalization) whenever possible.

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VI. Reducing Patient Stress

- Physical therapists have an ethical responsibility to support the autonomy of patients, especially those who may have decreased abilities to make choices in their lives and particularly to set boundaries around their bodies.

Differential Diagnosis

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Diagnostic groups

Differential Diagnosis: Hindfoot

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Insufficient dorsiflexion with:

I. Neutral hindfoot

II. Pronated hindfoot

III. Supinated hindfoot

I. Neutral Hindfoot

17

Limited DF range, without significant coronal or transverse plane findings

Associated gait patterns:

17

Toe walking

Excessively reclined shank

Casting considerations:

- Prone casting may provide a better lever-arm for effective GS stretch.

17

II. Pronated Hindfoot

17

- false “DF” (foot toward tibia) occurs through the subtalar and midfoot joints

II. Pronated Hindfoot

18

Hindfoot pronation is relatively more flexible than TC DF

II. Pronated Hindfoot

18

Medial rotation throughout the movement system

Associated with:

18

- Relative stiffness for hindfoot supination versus pronation
- Hypermobility at midfoot structures and first ray
- Decreased hip and knee extension during stance and altered gait

II. Pronated Hindfoot

19

May present with supinated posture in non-weightbearing

II. Pronated Hindfoot

19

Altered function of muscles, loss of response for balance around ankle

May be paired with excessive shank inclination

- Lack of ankle DF with knee extension moment at terminal stance
- Lack of hip extension

19

Casting considerations:

- Structural forefoot varus and adductus are often present
- Medial tibial torsion, varus of the tibia or LE system may be present

Casting considerations: 20

- Must accommodate for structural variants
- Must be precise to avoid stretching compromised structures and stretch true DF
- Compromised joints need to be protected by positioning in closed pack position during hindfoot casting
- Cast may need to be toward inversion first if TC DF is not achieved

III. Supinated Hindfoot 20

III. Supinated Hindfoot 20

Lack of mobility in the TC joint is NOT compensated for within the foot or ankle.

Ground reaction forces during initial contact and weight acceptance through an inflexible foot/ankle translate up the kinetic chain.

Associated with: 21

- Prominent head of the talus laterally
- Limited eversion ROM
- Restricted plantar fascia
- Restricted midfoot mobility

Associated with: 21

- Toe or flat contact at initial contact
- Extension versus flexion moment at loading response
- Lack of ankle DF and hip extension with knee extension moment at terminal stance(hip flexes and stride shortens)

Associated with: 21

Attempt to use long flexors for balance with toe gripping

Casting Considerations: 22

Manual therapy to the foot/ankle complex prior to casting may be key to progress

Associated with: 22

**Knee extension moment for stance can be adaptive for stability in stance when knee extensors are compromised

Examination

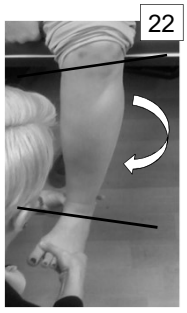
Examination

22

Structural Variants

Leg

- Torsions



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Structural Variants

Leg

Torsions (masked)

Torsion (+ varum)

23



Structural Variants
Leg
Varum

23


23

Structural Variants
Leg
- Valgum

Structural Variants

- Hindfoot
- Altered position or structure of malleoli

23

23

Posteriorly set lat. malleolus (versus tibial torsion)

…the case of the missing malleoli?

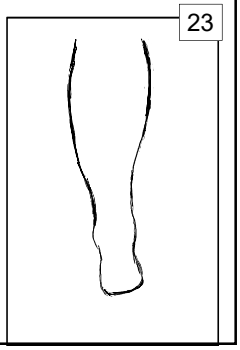
23

Structural Variants

Hindfoot

Calcaneal alignment

23



Structural Variants

Midfoot, forefoot

Tarsal coalition (hindfoot/midfoot)

Transverse plane

Forefoot adductus

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Structural Variants

Midfoot, forefoot

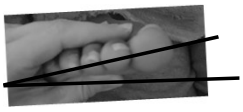
Frontal plane

Forefoot varus

(vs. limited midfoot mobility)

*Dropped first ray may obscure

24



Examination

24

- Structural variants MUST be noted for casting set up. The patient and therapist must be positioned to ensure that DF is occurring at the TC joint during casting.
- The system will try to “trick” the therapist to apply forces through the past of least resistance, further compromising fragile structures and leaving true DF unchanged.

Examination

25

Musculoskeletal Impairments

- Hyper, hypo-mobilities
- Relative flexibility/stiffness

Examination

25

Musculoskeletal Impairments

Alignment of:

- Subtalar joint
- Midfoot
- Soft tissue
- Forefoot
- Digits

25

Examination: Neuromotor

25

Ability to:

- Initiate contraction
- Maintain contraction against required force
- Relax
- Time and coordinate movement

Tonic Muscle Contraction

25

Demonstration and lab

26

Position of patient,
therapist 1, therapist 2

Demonstration

26

Position of patient,
therapist 1, therapist 2

Demonstration and lab

26

Lower extremity examination, evaluation, and manual intervention to address ankle alignment and dorsiflexion in preparation for casting

Demonstration and lab

26

Weightbearing examination

Demonstration and lab

26

Non-weight bearing examination

Position: prone, supine, sitting?

Demonstration and lab

27

Non-weight bearing examination

- Integumentary

Demonstration and lab

27

- Bony structure

Demonstration and lab

27

Muscular activity and length

-identifying stiff, short, and tonic contraction vs. “tight”

- Techniques to address patient stress, guarding, and tonic muscle contraction

Soft tissue extensibility

- Techniques to improve soft tissue mobility

Demonstration and lab

27

Muscular activity and length

-identifying stiff, short, and tonic contraction vs. “tight”

- Techniques to address patient stress, guarding, and tonic muscle contraction

Soft tissue extensibility

- Techniques to improve soft tissue mobility

27

- Techniques to address patient stress, guarding, and tonic muscle contraction
- -unweighting
- -deep pressure
- -contact on the active structures
- -movement into tone-inhibiting positions
- -NOT yelling at them to relax
- *Cast should replicate this calming input

Demonstration and lab

27

- Techniques to improve soft tissue mobility

Demonstration and lab

28

Alignment and joint motion: hindfoot, midfoot, forefoot

- Techniques to improve joint alignment and mobility

Demonstration and lab

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Talocrural range of motion *without compensatory motion*

1. Dorsiflexion Stress Test
2. Blocking compensatory motion
3. Determining the axis and range of TC DF

Demonstration and lab

28

1. Dorsiflexion Stress Test

Demonstration and lab

29

2. Blocking compensatory motion

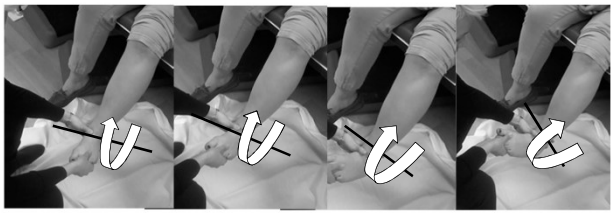
Demonstration and lab

29

3. TC Axis Test:
Determine
-axis
-range
-limiting structures
-end feel

29

29



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Demonstration and lab

30

Preparatory Treatment:
Addressing
-axis
-range
-limiting structures
-end feel

Demonstration and lab

30

Dorsiflexion goniometry: techniques to improve intra- and inter-rater reliability

30

Aligning Casts for Therapeutic Gait

30

Review of Key Gait Concepts

30

Loading response:
Flexion moment at the knee
Posterior chain is on stretch

Weight acceptance:
Flexion moment at the knee

Review of Key Gait Concepts

31

Midstance and quiet standing:

Weight line: anterior to the knee
posterior to hip

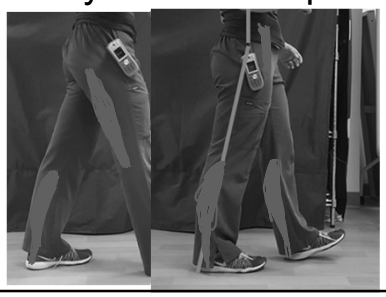
Mild incline of the shank

Review of Key Gait Concepts

31

Terminal Stance

GS, hip flexors on stretch



31

Terminal Stance

- heel in contact as the knee and hip extend

Aligning Casts for Therapeutic Gait

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Aligning Casts for Therapeutic Gait

32

2 angles within a cast:

- Angle of the ankle in the cast
- Angle of the shank (lower leg) to the floor: determined by gait training or weightbearing goals.

Differential Diagnosis: Gait

32

Insufficient dorsiflexion with:

I. Shank angle within functional limits

II. Excessively inclined shank (crouch)

III. Excessively reclined shank (knee hyperextension)

IV. Primary knee extensor insufficiency

I. Shank angle within functional limits (toe walking)

33

Movement system not impacted proximal to foot/ankle

I. Shank angle within functional limits

33

Movement system is able to compensate for limited DF

-or-

Movement system is ***driving*** the DF limitation

Goals for cast alignment:

- Hindfoot weightbearing
- Heel contact at initial contact
- Increase step length and time in terminal stance

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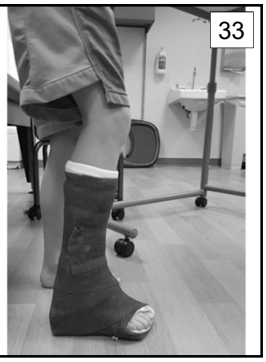


I. Shank angle within functional limits

34

DF limitation is likely to reoccur if initial driver is not addressed

II. Excessively inclined shank (crouch)

34

Weight line is anterior to the hip and posterior to the knee.

All of the GRF moments are flexion, in all phases of gait.

II. Excessively inclined shank (crouch)

34

Old conventional wisdom: set shank in a negative angle to push the shank backwards.

In reality, the foot has an inefficient lever arm for this to be effective, and the patient lifts the heel.

II. Excessively inclined shank (crouch)

35

Current theory: Bring the floor up to the heel to provide:

- Heel contact at initial contact and midstance
- Provide a base for the thigh to move from reclined to inclined

35

- Begin to each the motor system to load through the posterior aspect
- Compromise towards the chosen shank angle to get heel contact

35

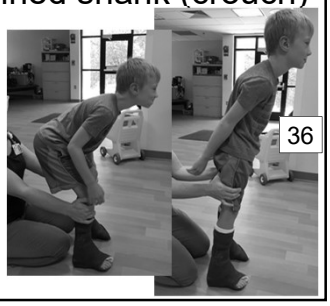
- Gradually reduce the shank angle as posterior structures lengthen and motor learning occurs

35

- Gradually reduce the shank angle as posterior structures lengthen and motor learning occurs

II. Excessively inclined shank (crouch)

Treatment focuses on learning to bring the thigh from reclined to inclined over a stable base in midstance and quiet stance.



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III. Excessively reclined shank (knee hyperextension)

36

Reversal of the forces around the knee during initial contact and weight acceptance, causing a knee extension moment.

36

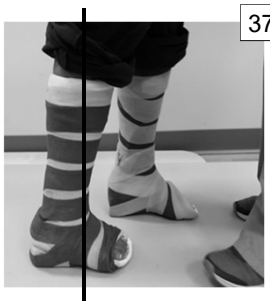
37

- Goal: bring the shank angle forward enough to overcome the tendency for the system to create an extension moment.

37

Treatment: bring shank forward to block the knee extension moment at loading response so that the patient experiences:

1. Flexion moment at loading response.
2. Weight line posterior to the hip in quiet stance.



IV. Primary knee extensor insufficiency

37

- Weight line is aligned anterior to knee to maintain knee stability
- Shank angle be reclined
- Associated with muscular dystrophies

Beyoncé. **Instagram,** 2017, https://www.instagram.com/p/BP-rXUGBPJa/

Aligning Casts for Therapeutic Gait

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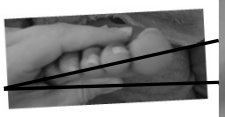
Aligning for weightbearing in the coronal plane

- Hindfoot

Forefoot
Coronal plane



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Aligning Casts for Therapeutic Gait

Forefoot
Sagittal plane
Position
Rigidity

38

38

Aligning Casts for Therapeutic Gait

38

Aligning Casts for Therapeutic Gait

38

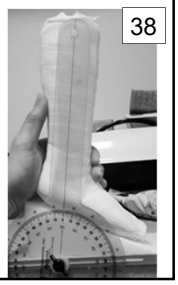
Angle of the post inside the cast

=

Degrees lacking to neutral DF

+

Desired shank angle



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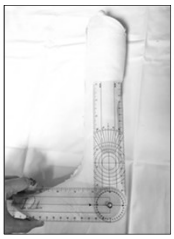

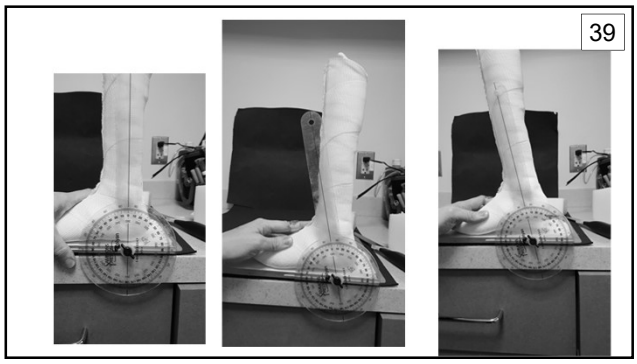
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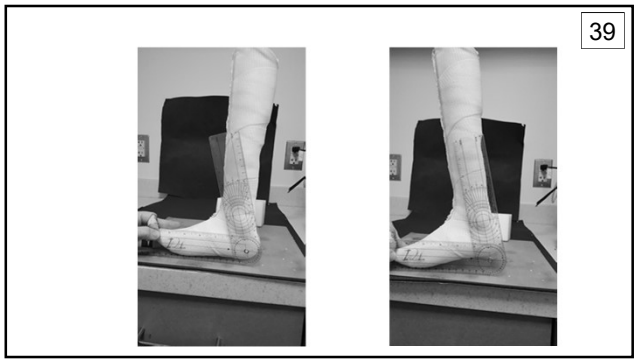
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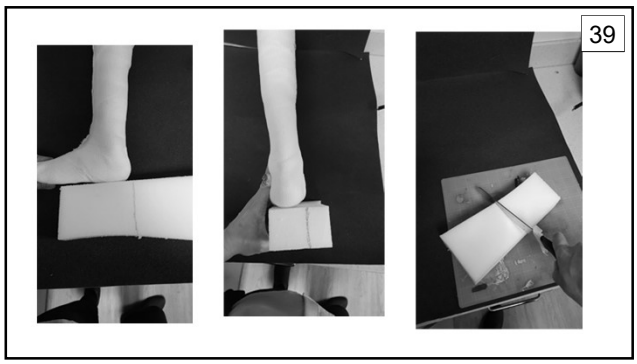
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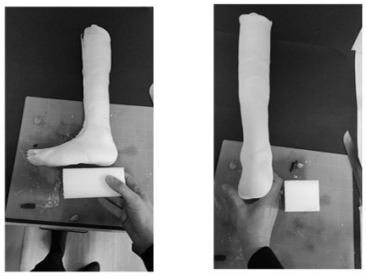

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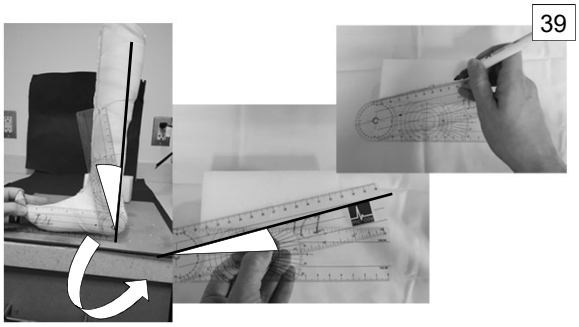

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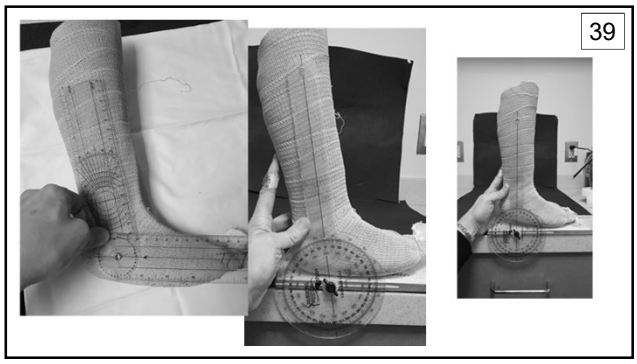
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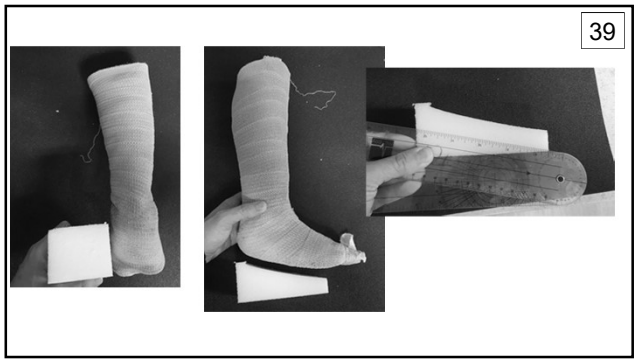
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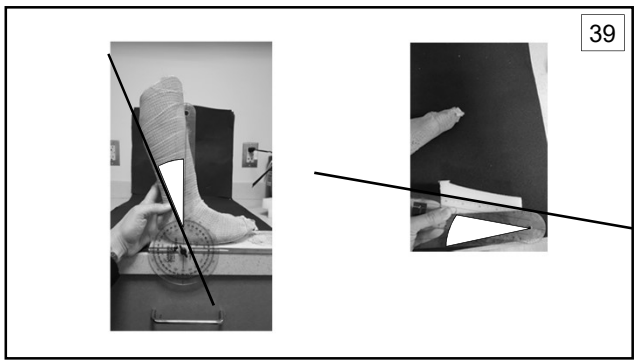
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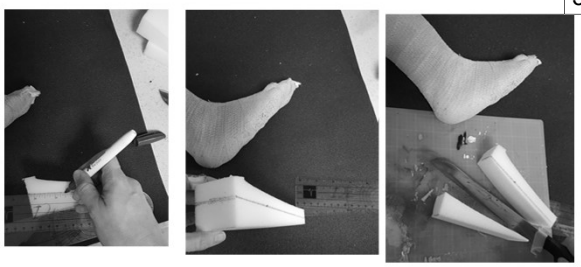

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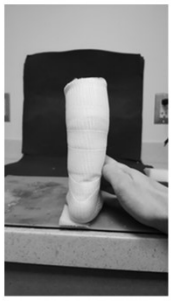

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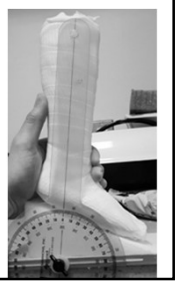
Aligning Casts for Therapeutic Gait

Case study problems (2 dimensional patients)



Casting techniques

39

Casting techniques

39

1. Creating an anchor
2. Circumferential wrapping
3. Use of elastic tension and direction of pull to influence tissue and joint mobilization
4. Creating a heel lock

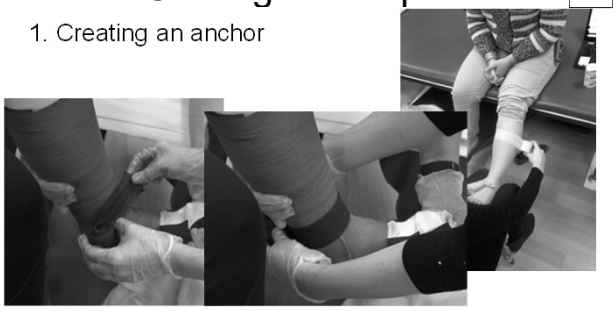
-inversion

-eversion

Casting techniques

39

1. Creating an anchor



Casting techniques

39

2. Circumferential wrapping

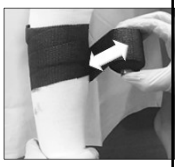
- Holding roll center to control tension
- % of overlap

Casting techniques

39

3. Use of elastic tension and direction of pull to influence tissue and joint mobilization

-"roll off", 50%, 90%, no tension



Casting techniques

39

3.

First layer, over fleshy areas:

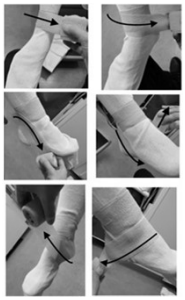
- needs to be consistent to avoid tourniquet. Generally "roll off" tension
- Direction of wrap can be important

Hindfoot: variable tension, variable direction of wrap

Casting techniques

39

4. Creating a heel lock
-inversion
-eversion



Casting techniques

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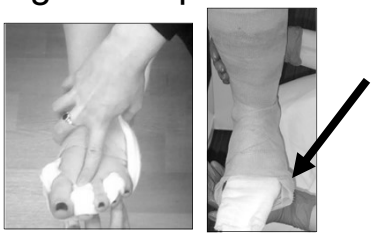
5. Use of spacers



Casting techniques

40

6. Selective reinforcement (creating a “stay”)
7. Combination of materials

Casting techniques

40

8. Forming a contoured forefoot support



Casting techniques

40

9. Posting for weightbearing


Casting Materials: Plaster

40

Rigid after 24 hours.

Can be reinforced with fiberglass externally until completely set to prevent cracking.

Highly moldable, wrinkles easily, requires use of webril for padding; increased cast application time.

Casting Materials: Plaster

40

Increased weight.

Requires cast saw to remove.

Cast must be well padded.

Wrinkles in material can cause pressure sores.

Material will crack if joint position is changed during casting.

Casting Materials: Fiberglass

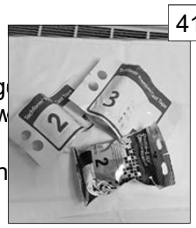
41

Rigid

Removes via hook blade or bandag scissors when semi-set, or cast saw when set, or thickly layered.

Lay properties vary greatly between products.

Used for taking molds to make orthoses, for traditional serial casting, or for focal reinforcement.



Casting Materials: Fiberglass

41

Requires sharp scissors, blade, or cast saw to remove.

Requires competency/training for safety.

Cast must be padded or cutting strip used.

Cut edges become razor sharp and can pierce through padding.

Casting Materials: “soft” cast products

41

Most flexible

Remove via unwrapping

Properties vary between products

Those with elastic properties can be used to apply rotation force during casting

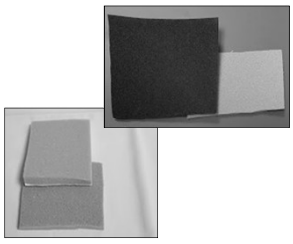
May require reinforcement

Casting Materials: Padding materials

42

Consider:

thickness, density, elastic qualities, firmness, resiliency, strength of adhesive



Padding

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- all boney prominences
- weightbearing surfaces
- areas where sensitive structures sit beneath the skin (e.g. tendons along the dorsum of the ankle)
- areas where therapeutic force is applied through the cast or splint
- distal and proximal ends
- any additional areas of concern or fragile skin

Padding

42

- Padding that does NOT bottom out is required.
- pressure (as in a cast), CAN AND WILL lead to cast-induced pressure sore.

Stockinette and skin protectors

43

Cast Application 1

43

"Dry Run"

Cast Application 1

43

Keys:

- Position of patient and therapists
- Attention to directionality
- Segmental application
- Hindfoot mobilization
- Forming a contoured forefoot support

Cast Application 1

44

Partner A leads, B holds, C is casted

Group Activity

44

Review of casts: alignment, function, trouble-shooting and clinical fixes

Feedback from “patient”

Cast Application 2

44

Partner B leads, C holds, A is casted

Addition of stockinette, padding, casting materials

Group Activity

45

Review of casts: alignment, function, trouble-shooting and clinical fixes

Feedback from “patient”

Cast Application 3

45

Partner C leads, A holds, B is casted

Group Activity

45

Review of casts: alignment, function, trouble-shooting and clinical fixes

Feedback from “patient”

Questions

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Therapeutic Casting Forum

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