Pediatric Triple Action® Ankle Joint: Theory of Operation Fabrication & Clinical Application

Presented by:

Becker Orthopedic

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A Tradition of Excellence A Commitment to Innovation

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Triple Action® ankle joint was developed to enhance the clinical impact of orthotic care for a broad range of pediatric applications. Through this program, you will discover how this unique orthotic component can raise the level of your clinical practice, while creating opportunities for collaboration with other allied healthcare professionals.

This accredited online learning program covers the Theory of Operation, as well as the Technical and Clinical Applications of the Pediatric Triple Action ankle joint.

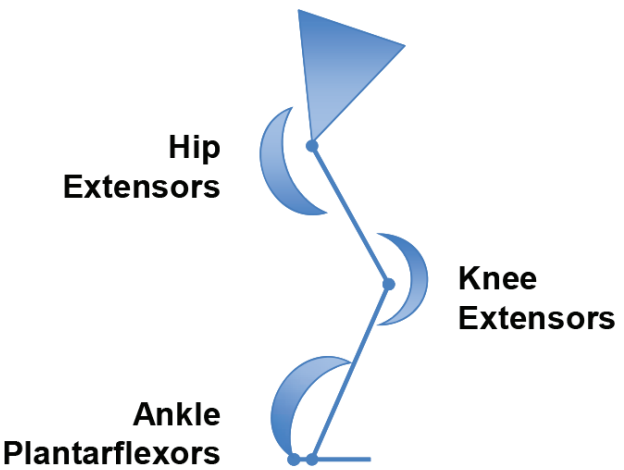
The program will begin with a general discussion of Pediatric AFO Functional types.

Pediatric AFO Sagittal Plane Function

AFOs

Directly influence motion at the Ankle

Indirectly influence motion at the Knee



AFOs directly influence ankle motion by applying forces across the ankle joint in threepoint bending. These orthoses indirectly influence knee motion by manipulation of the ground reaction force with respect to the knee axis.

Pediatric AFO Sagittal Plane Function

The sagittal plane influence of AFOs results from:

Ankle Alignment

- Fixed
- Adjustable (by Modification to AFO or Variable Position Stop)

Resistance to Ankle Motion

- Stop Motion (High Resistance)
- Permit Resisted Motion (Fixed or Adjustable)
- Permit Free Motion (Low Resistance)

This orthotic influence at the ankle and knee results from the AFO's ankle alignment and resistance to ankle motion. This influence may be fixed, or adjustable.

Pediatric AFO Functional Types

Images courtesy of Orthomerica Products, Inc.

		Active Resisted Ankle Motion	•Plantarflexion Spasticity •Knee Hyperextension	• Knee Flexion Instability • Crouch Gait	Complex or Changing Ankle/Knee Deficits
Leaf Spring	 • Active PF/DF Resist • Fixed Alignment	●			
Plantarflexion Stop	 • Blocks PF • Free DF • Fixed OR Adjustable PF Stop Alignment		●		
Dorsiflexion Stop	 • Free PF • Blocks DF • Fixed DF Stop Alignment			●	

There are many types of pediatric AFOs, but the sagittal plane influence of all types may be represented by some combination of the leaf spring, plantarflexion stop, and dorsiflexion stop orthosis. Leaf spring AFOs permit active, resisted ankle motion when the ankle moves away fromthe fixed ankle alignment of the orthosis. These orthoses are commonly used to treat mild swing phase gait deficits, as well as foot and ankle postural abnormalities.

Plantarflexion stop AFOs provide high resistance to plantarflexion at a fixed, or adjustable flexion angle while permitting free dorsiflexion. These AFOs find application in the treatment of spastic equinus with, or without knee hyperextension. Plantarflexion stop orthoses are not used to treat knee flexion instabilities, or spasticity.

Dorsiflexion stop AFOs provide high resistance to dorsiflexion at a fixed flexion angle, while permitting free plantarflexion. Dorsiflexion stop orthoses are used to treat knee flexion instabilities resulting from knee extensor insufficiency, or crouch gait resulting from knee flexion spasticity or contracture. Dorsiflexion stop orthoses are not used to treat plantarflexion spasticity, or when there is spastic co-contraction at the knee, such as in jump gait.

Pediatric AFO Functional Types

Images courtesy of Orthomerica Products, Inc.

		Active Resisted Ankle Motion	•Plantarflexion Spasticity •Knee Hyperextension	• Knee Flexion Instability • Crouch Gait	Complex or Changing Ankle/Knee Deficits
Leaf Spring	 • Active PF/DF Resist • Fixed Alignment	●			
Plantarflexion Stop	 • Blocks PF • Free DF • Fixed OR Adjustable PF Stop Alignment		●		
Dorsiflexion Stop	 • Free PF • Blocks DF • Fixed DF Stop Alignment			●	
Solid	 • Blocks PF • Blocks DF • Fixed Ankle Alignment		●	●	

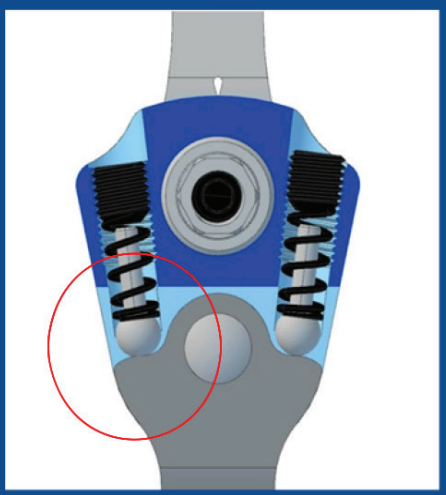
The solid AFO is the combination of plantarflexion and dorsiflexion stop types. These orthoses have fixed ankle alignment. Solid AFOs are typically used for static positioning to maintain range of motion, or to provide support for the ankle and knee when combined with tuned shoe rocker modifications.

Pediatric AFO Functional Types

Images courtesy of Orthomerica Products, Inc.

		Active Resisted Ankle Motion	• Plantarflexion Spasticity • Knee Hyperextension	• Knee Flexion Instability • Crouch Gait	Complex or Changing Ankle/Knee Deficits
Leaf Spring 	• Active PF/DF Resist • Fixed Alignment	●			
Plantarflexion Stop 	• Blocks PF • Free DF • Fixed OR Adjustable PF Stop Alignment		●		
Dorsiflexion Stop 	• Free PF • Blocks DF • Fixed DF Stop Alignment			●	
Solid 	• Blocks PF • Blocks DF • Fixed Ankle Alignment		●	●	
Triple Action® 	• Adjustable Active PF Resist • Adjustable Active DF Resist • Ankle Motion Limiters • Adjustable Alignment	●	●	●	●

Triple Action AFOs provide features found in the other functional types in addition to independently adjustable resistance, range of motion and alignment adjustments. These orthoses are well suited to the management of complex, combined, or changing ankle and knee deficits. Triple Action AFOs can be used to actively treat plantarflexion spasticity, knee hyperextension, knee flexion instabilities, or crouch gait. They are also suitable for post-surgical support and can be used for contracture management.



Pediatric Triple Action® Ankle Joint Theory of Operation

This discussion is focused on the Theory of Operation and is intended to help explain how this unique orthotic component can be used to impact the design and function of pediatric AFOs.

What's Different?

Double Action Ankle Joint

To explain how the Triple Action works, its operation will be compared to the more familiar double action ankle joint.

Theory of Operation: Double Action

Posterior Channel
Dorsiflexion Assist
OR
Plantarflexion Stop

Posterior springs OR Pins

Anterior Channel
Plantarflexion Assist
OR
Dorsiflexion Stop

Posterior springs OR Pins

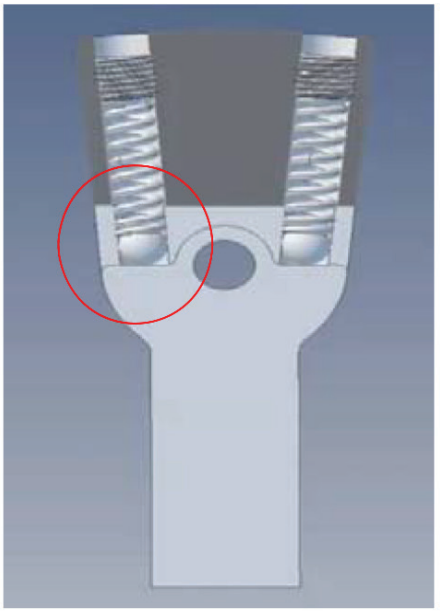
Double Action Ankle Joint

The double action is a versatile orthotic component that can be used to assist, or block ankle motion depending on whether springs, or pins are installed in its anterior and posterior channels. Double action springs provide moderate resistance to ankle motion, making them best suited to the management of mild swing phase gait deficits. These springs permit a high range of active motion, and so are best suited for patients with low activity levels.

Theory of Operation: Double Action

Animation

Double Action Ankle Joint



Double Action springs maintain contact

This animation illustrates how the stirrup moves inside the double action ankle joint. Note that as the stirrup moves, the springs maintain contact with the stirrup head throughout its entire range of motion.

Theory of Operation: Double Action

Double Action Ankle Joint

Double Action Assist, Range of Motion and Alignment are Inter-dependent

Interdependence between springs decreases resistance

And shortens their service life

The design of the double action links the springs together through the stirrup head and makes the dorsiflexion assist, plantarflexion assist and alignment functions interdependent. This interdependence reduces the component's effective resistance to ankle motion and may significantly shorten the service life of the springs.

What's Different?

Although the Triple Action ankle joint resembles the Double Action in its outward appearance, it functions very differently on the inside.

Theory of Operation: Triple Action®

Posterior Channel
Plantarflexion Resist
AND
Plantarflexion Stop

Posterior springs have
Internal Pins

TRIPLE ACTION®
Pediatric Ankle Joint

Anterior Channel
Dorsiflexion Resist
AND
Dorsiflexion Stop

Anterior springs have
Internal Pins

The Triple Action is a highly versatile orthotic component that can be used to resist, or block ankle motion. Triple action springs contain internal motion limiting pins in the anterior and posterior channels. Since Triple Action springs provide high resistance to ankle motion, they are well suited to the management of severe swing and stance phase gait deficits. Triple Action springs are highly durable, making them an ideal choice for the most active patients.

Theory of Operation: Triple Action®

Animation

Triple Action springs Do Not maintain contact

This animation illustrates how the stirrup moves inside the Triple Action ankle joint. Note that as the stirrup moves, the springs make and break contact with the stirrup head.

Theory of Operation: Triple Action®

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Pediatric Ankle Joint

Triple Action Resist, Range of Motion and Alignment are <u>In-dependent</u>

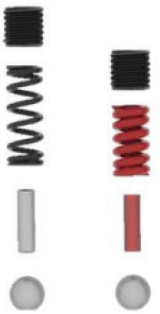
This independence increases resistance

And helps to increase spring cycle life by <u>more than 20 times</u>

This make and break contact isolates the action of the springs, allowing the resistance, range of motion and alignment functions of the Triple Action to be independent. This design increases the active resistance of the component and also helps increase spring cycle life by more than twenty times when compared to traditional metal ankle components.

Resistance Spring Options

Triple Action has high resistance springs with two spring options



Spring No.	1	2
Resist	Low	Mod
ROM	15°	8°

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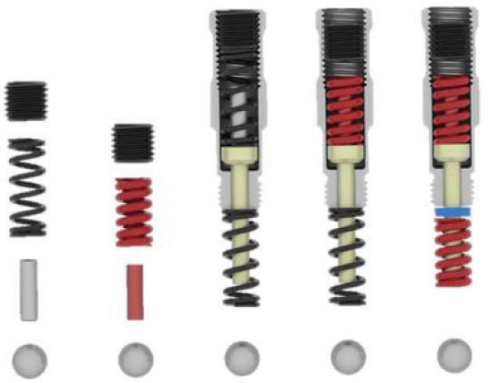
Pediatric Ankle Joint

Triple Action springs provide higher resistance than double action springs. All Triple Action ankle joints come standard with two spring options; spring one (standard resist) and spring two (high resist).

Resistance Spring Options

With addition of the Booster Spring (SRA), 5 unique spring configurations are possible



Spring No.	1	2	3	4*	5
Resist	Low	Mod	Mod	High	Very High
ROM	15°	8°	15°	15°	8°
*Staged Resist					

With Booster Spring SRA

With the addition of the optional Booster Spring Staged Resist Adapter, or SRA, a total of five unique spring configurations are possible.

Resistance Spring Options

Plantarflexion Resist

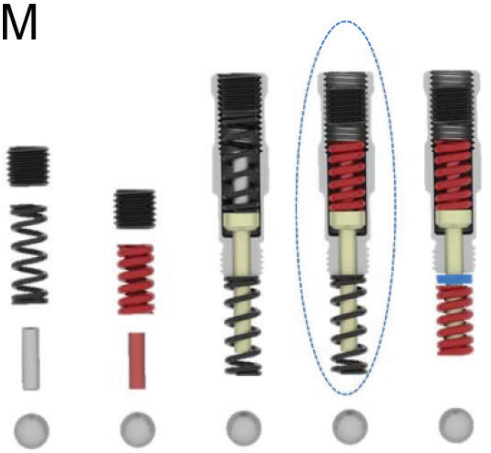
Dorsiflexion Resist

Or Both Spring Channels

The Booster spring SRA can be installed in the plantarflexion resist, dorsiflexion resist, or both spring resist channels.

Resistance Spring Options

The SRA also gives the Triple Action 'Staged Resist' capability; the ability to change its resistance as the stirrup articulates through its ROM



Spring No.	1	2	3	4*	5
Resist	Low	Mod	Mod	High	Very High
ROM	15°	8°	15°	15°	8°
*Staged Resist					

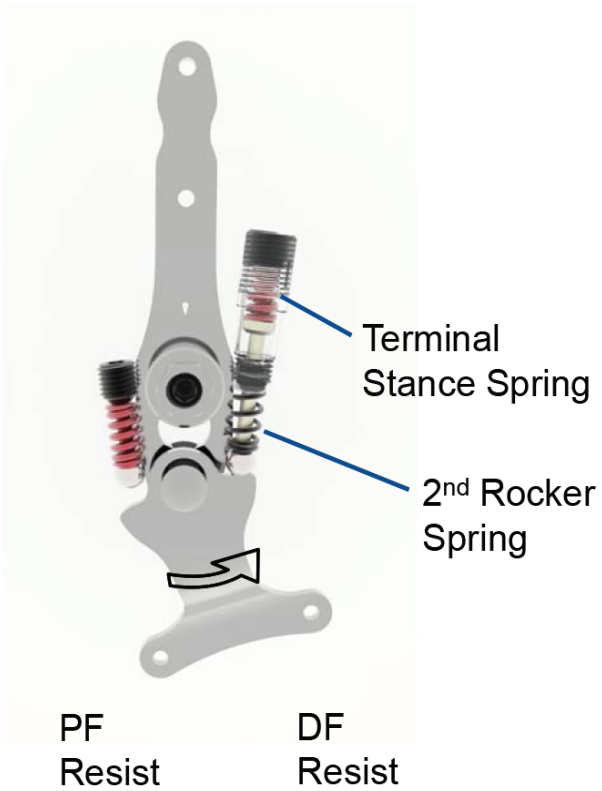
TRIPLE ACTION®
Pediatric Ankle Joint

Booster Spring configuration number four also gives the Triple Action the unique ability to vary its resistance as the stirrup moves through its range of motion. This feature is called 'staged resist'. The ankle angle at which this change of resistance occurs is adjustable when tuning the Triple Action in the clinical setting.

Resistance Spring Options: Staged Resist

The black standard resist spring initially resists articulation as the stirrup moves toward dorsiflexion.

This is similar to eccentric contraction of soleus through 2nd rocker.

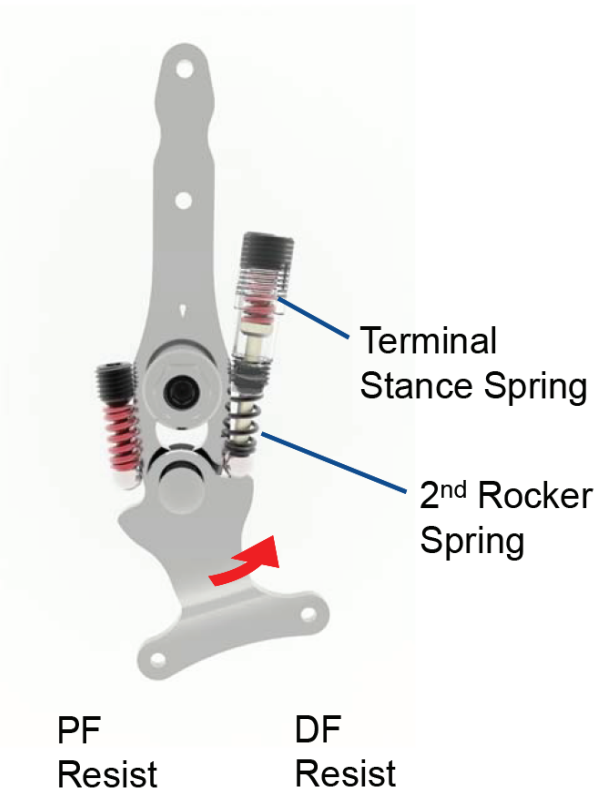


This slide illustrates the staged resist feature of the Triple Action ankle joint. As the stirrup begins moving away from its null position towards dorsiflexion, the black spring under the Booster Spring SRA begins resisting motion.

During the second rocker of gait, this resistance may substitute for the eccentric contraction of the gastrosoleus.

Resistance Spring Options: Staged Resist

Past midstance, the red high resist spring resists dorsiflexion also, to stabilize the knee without hyperextension.



At a clinically determined dorsiflexion angle, the red (high resist) spring inside the SRA also begins resisting motion.

This high active resistance may help to slow the progression of the tibia in late stance. The combined action of the two springs in the Booster Spring SRA can be tuned to stabilize the knee against flexion, while limiting hyperextension in late stance.

Range of Motion Adjustment

Range of motion is decreased by turning the adjustment screws clockwise

- ROM decreases 5° per turn
- Turning the adjustment screws fully clockwise locks the setting
- This is the 0° ROM reference setting for the component (locked)

This slide illustrates how to adjust range of motion. The range of motion in plantarflexion and dorsiflexion may be independently adjusted. Turning the adjustment screws clockwise decreases range of motion by five degrees per turn. With the adjustment screws tightened fully clockwise, the component's range of motion is locked at zero degrees. This is the reference setting for the component's range of motion adjustment.

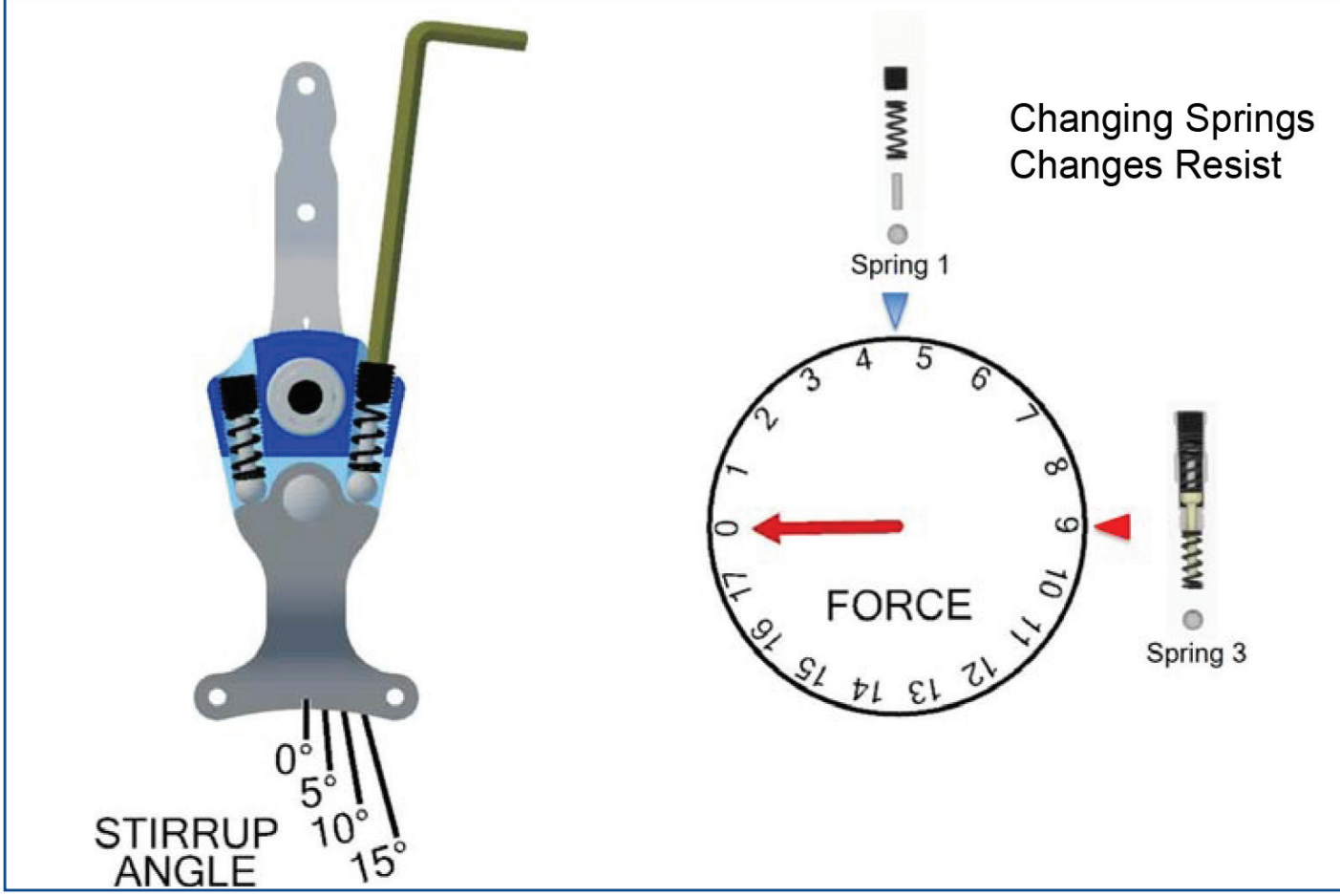
Range of Motion Adjustment

Range of motion is increased by turning the adjustment screws counter clockwise

- ROM increases 5° per turn
- The maximum ROM setting with respect to the locked setting is
  - 3-turns (15°) for the Standard Resist Springs (black)
  - 2-turns (8°) for the High Resist Springs (red)

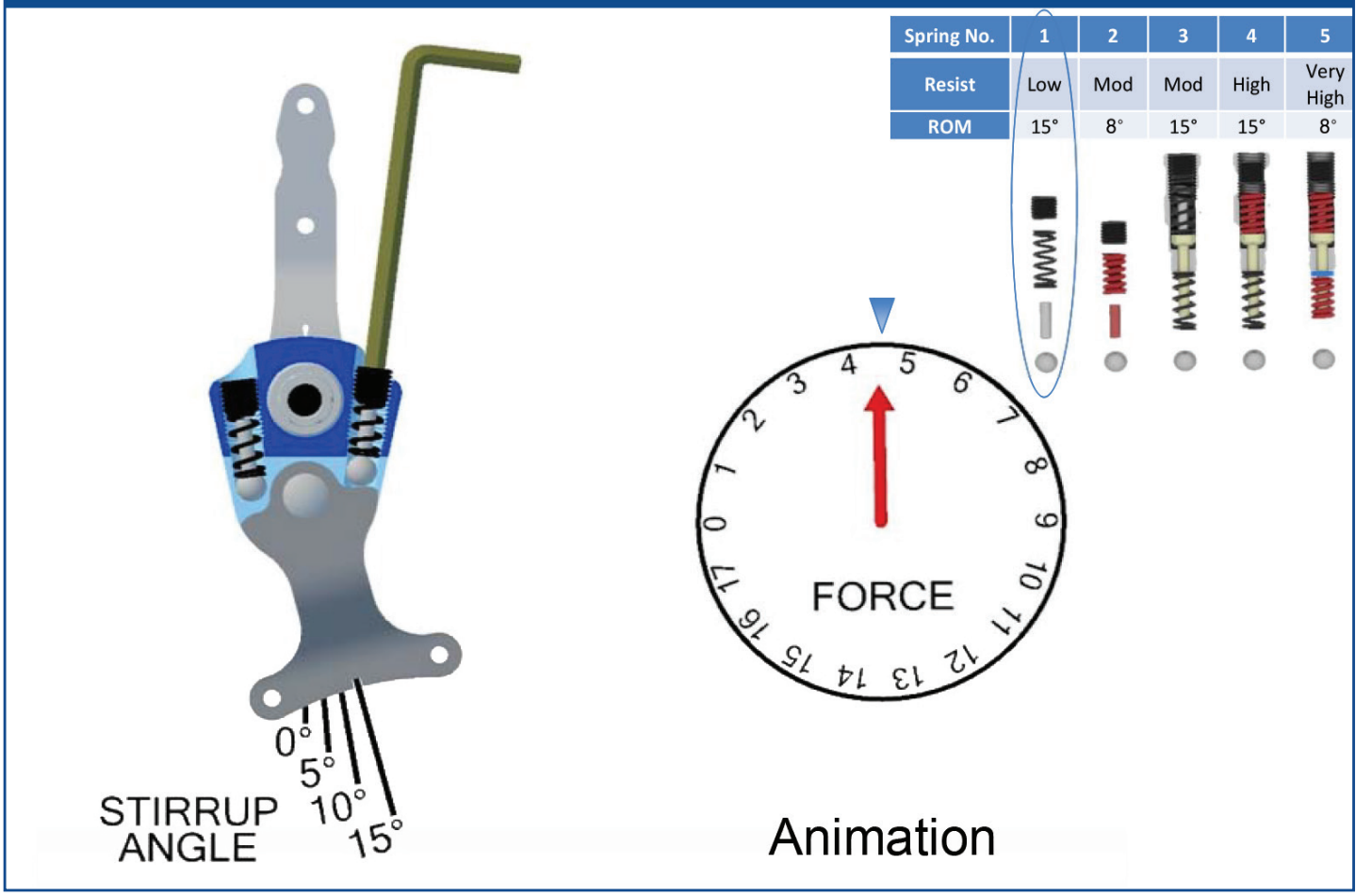
Turning the adjustment screws counter clockwise increases range of motion by five degrees per turn. The maximum active range of motion is fifteen degrees, or ten degrees depending upon which spring configuration is installed.

Resistance and ROM Functions



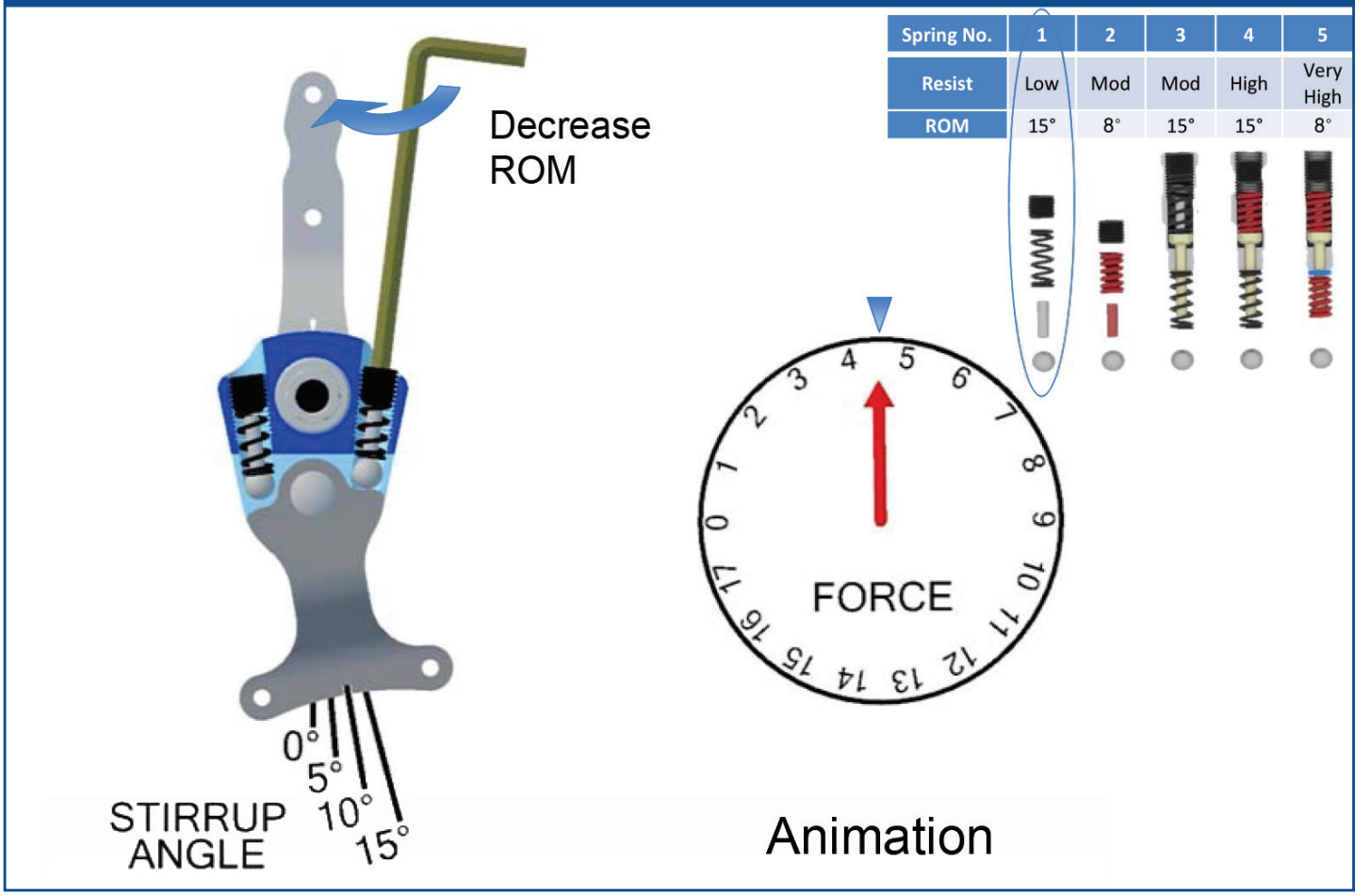
The following animation will illustrate the effects of the range of motion adjustment for two spring options; standard resist spring number one and booster spring number three. Booster spring number three exerts twice the force of spring number one. Please note that the units of force used in this illustration are arbitrary.

Resistance and ROM Functions



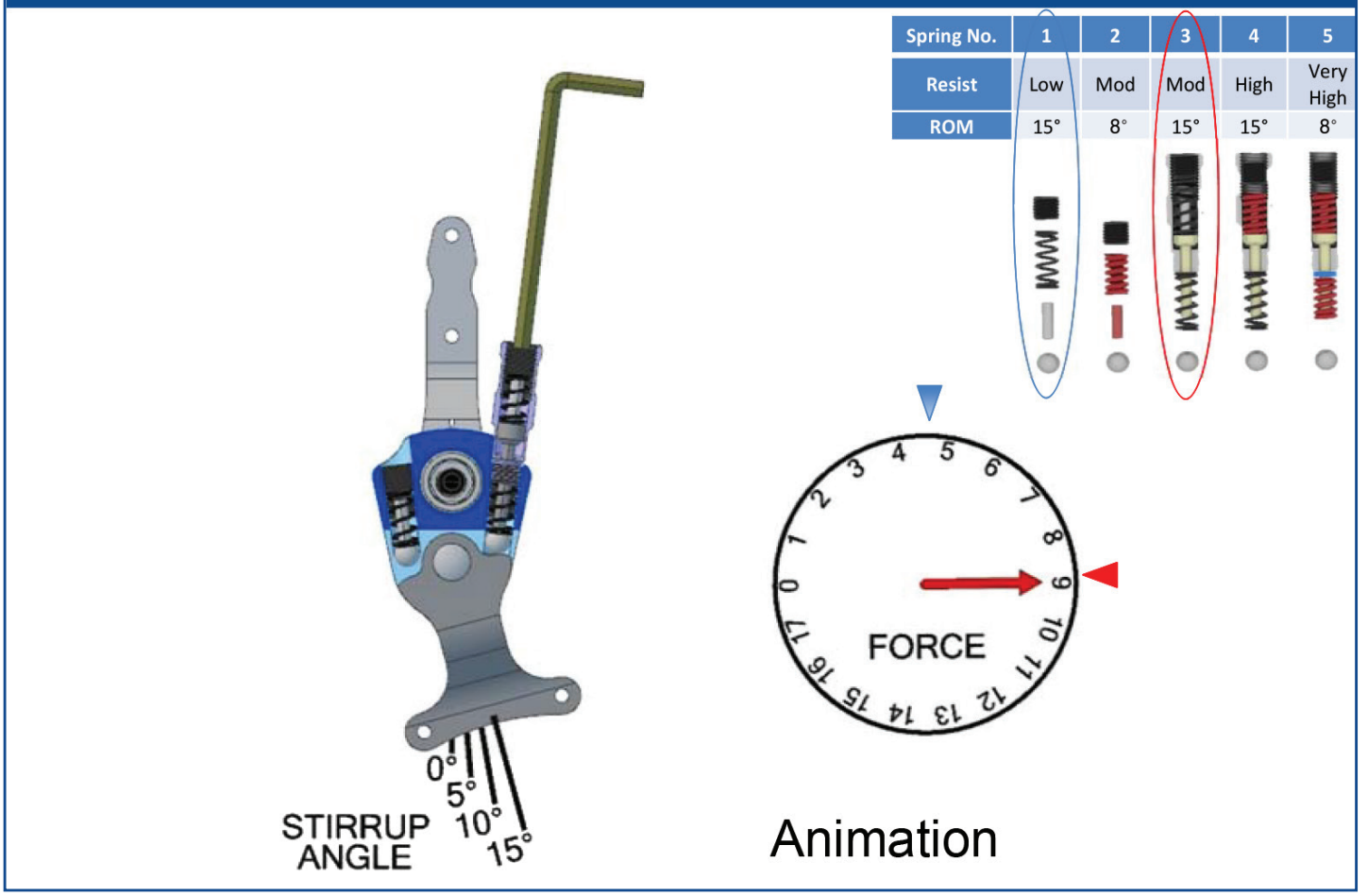
In this animation, the stirrup articulates between its null position and its initial range of motion setting of fifteen degrees. The maximum force exerted by standard resist spring number one is shown.

Resistance and ROM Functions



When the ROM adjustment screw is rotated one full turn clockwise, the range of motion decreases by five degrees, but the maximum force on the stirrup doesn't change. Note however that the preload force on the stirrup moving away from its null position does increase.

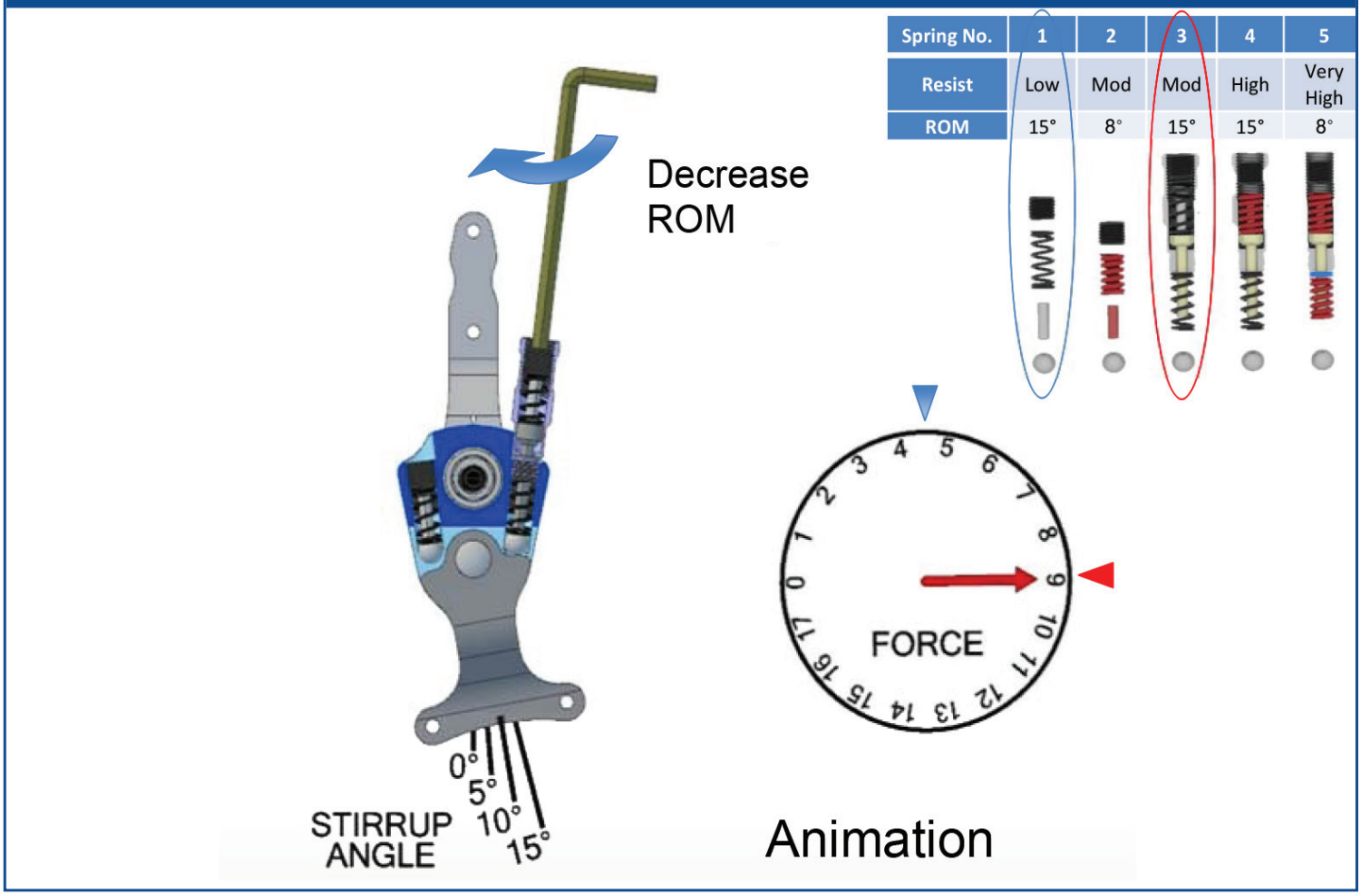
Resistance and ROM Functions



This animation illustrates that the maximum resistance of the Triple Action ankle joint is determined only by the spring configuration.

In this animation, the stirrup articulates between its null position and its initial range of motion setting of fifteen degrees. When Booster Spring number three is installed, the maximum force exerted is twice the amount of spring number one.

Resistance and ROM Functions



Rotating the adjustment screw one full turn clockwise, decreases the range of motion by five degrees, but again does not affect the maximum force.

Alignment Adjustment

The range of motion settings don't effect ankle alignment or resistance.

Alignment is independently adjustable.

The range of motion adjustment screws change the articulation range of the stirrup, but do not effect stirrup alignment.

Alignment Adjustment

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Pediatric Ankle Joint

The Alignment setting rotates the component body about the pivot bushing to maintain the joint center.

Unlock

Adjust

The alignment setting rotates the component body about the pivot bushing, maintaining the joint center as the component articulates. The alignment feature is unlocked by loosening the central locking screw and adjusted by rotating the outer hex.

Tuning Procedure

The independent action of Resist, ROM and Alignment:

- Systematically influences gait variables
- Facilitated development of the standard Tuning Procedure to simplify use

Tuning Procedure

Step 1. **Bench** Adjustment

Step 2. **Static** Alignment

Step 3. **Swing** Phase Alignment

Step 4. **Stance** Phase Adjustment

The independent action of resistance, range of motion and alignment have been shown to systematically influence gait in biomechanical studies. The effect of these component settings may also depend upon the nature of biomechanical deficits.

Separating the influence of component settings also facilitated the development of the Triple Action tuning procedure. This procedure helps to simplify adjustments in the clinical setting. The Triple Action tuning procedure resembles prosthetic alignment and will be described in greater detail later in this presentation.

Patient Care Impact

AFOs can help kids walk better and more independently. They can also help to maintain range of motion, or decrease pain following surgery. The Triple Action ankle joint was developed to maximize the clinical benefits of pediatric AFOs.

Features & Applications Summary

Features

- Independent Alignment
- Independent Range of Motion Adjustment
- Multiple Spring Options with High Active Resist
- High Durability Springs

Applications

- Active Ambulation with complex, combined and/or changing neuromuscular deficits
- Contracture Management
- Post Surgical Management

Indications

Lower extremity gait deficits as a result of:

- Cerebral palsy
- Spina Bifida
- UMN Lesion

The features of the Triple Action ankle joint include independent alignment, range of motion adjustment and multiple spring configuration options. Triple Action springs have high active resistance and are durable enough to keep up with the most active patients.

The Triple Action is effective at managing high activity patients with complex, combined, or changing neuromuscular deficits. Indications include lower extremity gait deficits as the result of cerebral palsy, spina bifida and other pathologic neuromuscular conditions.

Triple Action® Applications

The Triple Action can be used to treat pediatric patients through all stages of orthotic management

The Triple Action was developed to treat pediatric patients through all stages of orthotic management.

Triple Action® Applications

- Stiffer springs permit active ankle and knee support
- Tuned settings don't change with use between follow ups
- Durable springs reduce maintenance visits

To improve the function of active ambulators without locking up the ankle.

Triple Action® Applications

Post-Surgical Care

- Rigidly immobilize the ankle after cast removal
- Optimize ankle angle for support following surgical release procedures
- Incrementally mobilize the ankle during rehabilitation

For rigid immobilization and pain relief after tendon release surgery, followed by incremental mobilization of the ankle during rehabilitation.

Triple Action® Applications

Contracture Management

- Gain additional ROM using the 20° alignment adjustment range after Botox® and serial casting
- Track adjustment settings to chart progress

And as an adjunct to Botox injection. The Triple Action's alignment feature has a twentydegree adjustment range and may be used to maintain range of motion after serial cast removal.

Triple Action® Applications

These three applications of the Triple Action ankle joint span the full range of pediatric lower extremity orthotic care and demonstrate the versatility of this unique orthotic component.

Triple Action® Clinical Impact

The Pediatric Triple Action was developed to improve the Clinical Impact of AFOs

And to affordably fit within your clinical practice

The Triple Action enhances the clinical impact of AFOs and provides an orthotic solution that fits within the current structure of healthcare reimbursement.

Coding and Reimbursement

L2220 (Double Action Ankle Joint Code)

Addition to lower extremity, dorsiflexion and plantar flexion assist/resist, each joint

L2999 (Alignment Feature Descriptor Wording)

Addition to lower extremity, independently adjustable, sagittal ankle alignment, each joint

Disclaimer: The coding opinion expressed is based upon information submitted for review and the clinical experience of the members of AOPA's Coding Committee. Neither AOPA nor its Coding Committee recommend or endorse products/devices of any manufacturer.

Regardless of the source of coding information, the final responsibility for correct coding within all established laws, rules, standards, and practices is the sole responsibility of the facility submitting the claim.

AOPA and its Coding Committee accept no responsibility for, and will not be liable for, any actions relating to this coding information.

Although correct coding is the sole responsibility of the facility assuming the insurance claim, suggested L-Codes for Triple Action billing are L2220, and L2999 for the addition of the alignment feature.

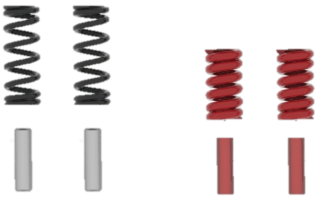
If the L2999 code is also used, we suggest the following wording be used as a descriptor: Addition to lower extremity, independently adjustable, sagittal ankle alignment, each joint.

Options & Accessories

Options and accessories are available for the Triple Action ankle joint to equip the clinician with the tools they need to help them tailor their orthotic design to the unique needs of their patient.

What's Included?

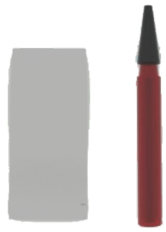
Two Spring Options



Installed *Included*

Attachment Screws
(M4x6 and M4x8)

Wrenches



Grease & Thread Locker

Two spring options, adjustment wrenches, metric attachment screws, lubricant and thread locking adhesive are included with the Triple Action ankle joint.

Stirrup Options

Lateral Stirrup

Medial Stirrup (Left or Right)

There are two stirrup options available; a universal lateral stirrup and a medial stirrup which is ordered specifically for the right or left leg.

Spring Options – Booster Spring SRA

Optional Booster Spring Staged Resist Adapter (SRA)

- Includes both Standard and High Resist Springs and motion limiter pins

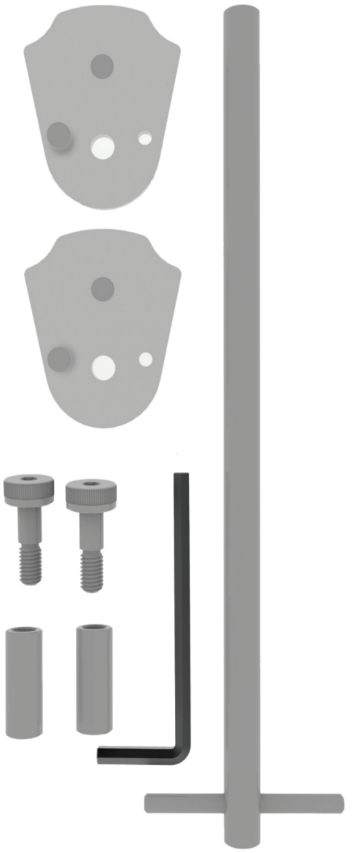
The Booster spring SRA is also available as an option and includes standard and high resist springs.

Accessories – Fabrication Tool Kit

Fabrication Tool Kit
Model 3C00-FTK

The fabrication tool kit includes:

- Alignment Axis (1)
- Fabrication Dummies (2)
- M6 Shoulder Screws (2)
- Alignment Bushings (2)
- 4mm Fabrication Wrench (1)

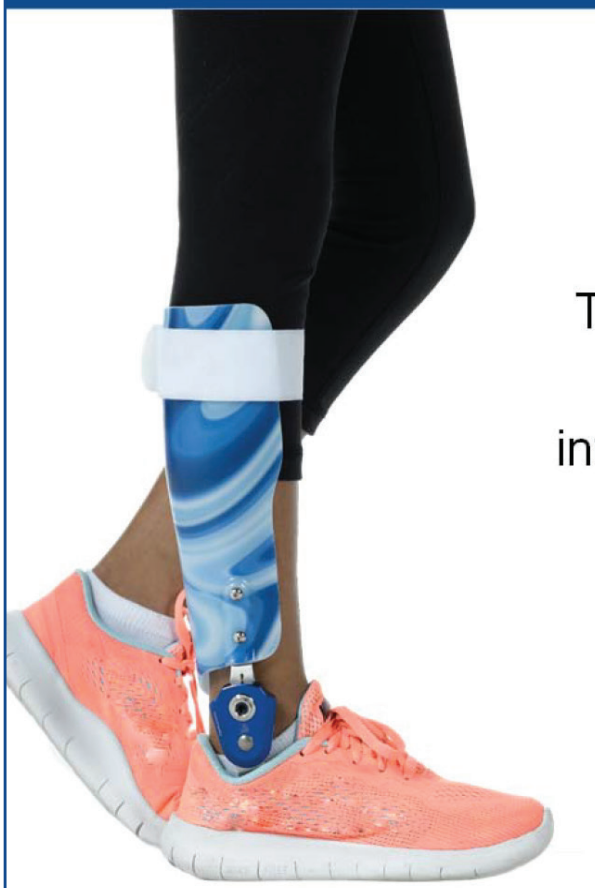


The fabrication kit includes an alignment axis, two component dummies, bushings, shoulder screws and wrench.

Orthotic Design

In this section, fundamental aspects of Triple Action AFO design will be discussed. The success of the clinical outcome starts with effective orthotic design.

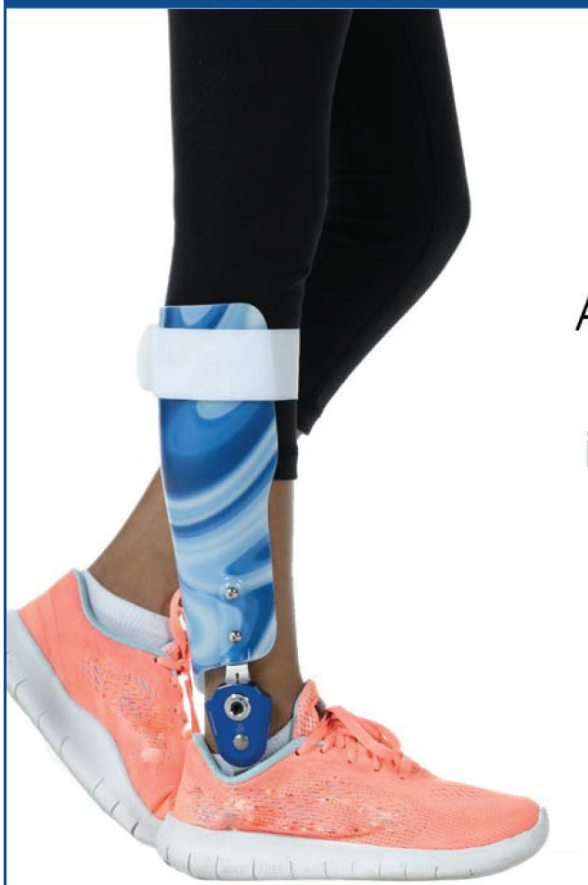
Orthotic Design Considerations



Triple Action AFOs must be rigid to systematically influence sagittal plane ankle and knee kinematics.

Triple Action AFOs must be rigid to systematically influence sagittal plane kinematics.

Orthotic Design Considerations



AFOs that are too flexible will decrease the systematic influence of the Triple Action ankle joint on gait.

AFOs that are too flexible will decrease the systematic influence of the component on gait.

Orthotic Design Considerations

Rigid orthotic designs are best

- Polypropylene sheet (4mm [5/32 inches]) is recommended for fabrication of Pediatric Triple Action AFOs
- Stiffeners at the distal calf section can be used to help stiffen the orthotic structure for larger AFOs
- Ventral (pretibial) shells with full length footplate are suggested for designs intended to treat knee flexion instabilities

Becker Orthopedic is engaged in testing aimed at improving the design and fabrication of Triple Action AFOs.

Rigid thermoplastic materials such as polypropylene, in a sheet thickness of 4mm (5/32 inch) are recommended. Stiffeners at the distal calf may also be used to increase stiffness depending on the shape of the limb, patient weight, calf diameter and neuromuscular tone.

Ventral, or pre-tibial shells are recommended with full length footplates for applications where knee flexion instability, or spasticity exists.

Orthotic Design Considerations

Composites are not recommended for Pediatric Triple Action AFOs.

The Pediatric Triple Action is not intended for use in composite AFO designs, or designs without a companion joint.

One Triple Action® or Two?

Patient Weight	Less than 31 Kg [75 Lbs]				31 – 43 Kg [75 to 95 Lbs]				43 – 50 Kg [95 to 110 Lbs]		Greater than 50 Kg [110 Lbs]
Spasticity	Low Spasticity		High Spasticity		Low Spasticity		High Spasticity		Low OR High Spasticity		
Configuration	1-Triple Action		1-Triple Action with Booster Spring		1-Triple Action with Booster Spring		2-Triple Actions with or without Booster Spring		2-Triple Actions with Booster Spring		Contact Clinical Support
Side	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	
Lateral Joint	3C76-LAT		3C76-LAT		3C76-LAT		3C76-LAT		3C76-LAT		
Medial Joint	740S-M-CAP		740S-M-CAP		740S-M-CAP		3C76-MEDL	3C76-MEDR	3C76-MEDL	3C76-MEDR	
Booster Spring SRA Option	3C00-SRA Optional		3C00-SRA Recommended		3C00-SRA Recommended		3C00-SRA Optional		3C00-SRA Recommended		

Note: 2-Triple Action components are recommended for all Post-Operative orthoses

The decision whether to use one or two Triple Action components for a particular AFO design should be based on patient weight, calf circumference and neuromuscular tone. This chart is intended to provide general guidelines for component selection for Pediatric Triple Action AFOs. The first consideration is patient weight. The patient's level of spasticity is then used to determine whether one, or two Triple Action components is appropriate, with or without Booster Spring SRA's.

One Triple Action paired with a medium Tamarack companion joint will be suitable for many applications. It is recommended, however, that all post-surgical AFO designs use two Triple Action components to ensure maximum stability, even for smaller, low tone patients.

Orthotic Design Considerations

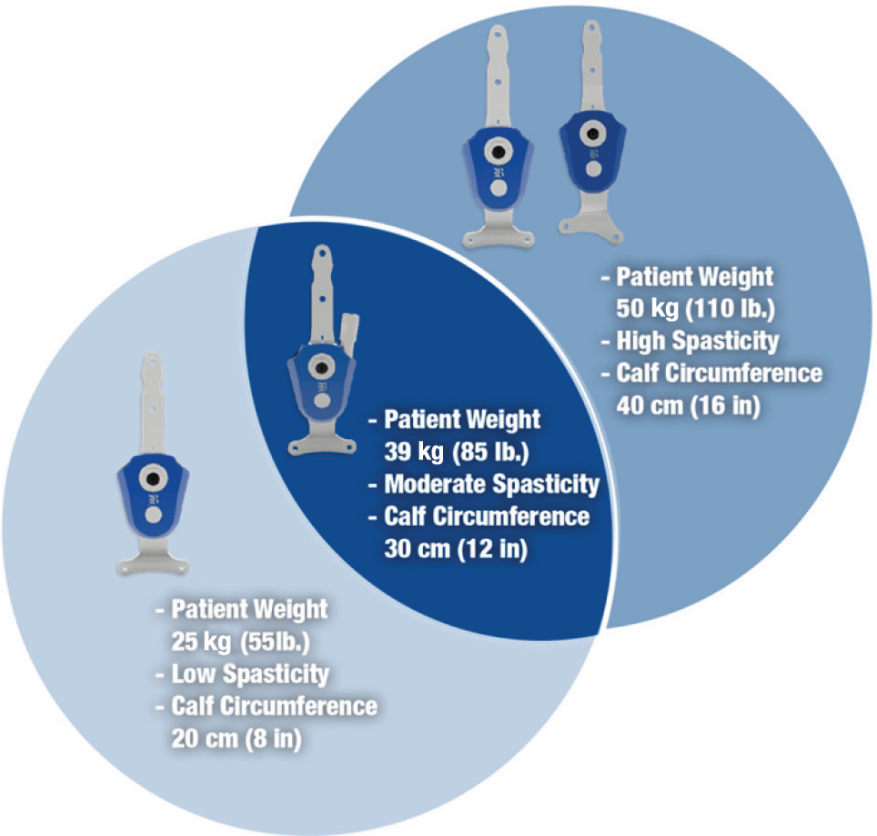
The maximum patient weight for the Pediatric Triple Action is 50 kg (110 lb), but this limit depends on spasticity, activity level and application.

Contact your clinical representative for applications assistance.

The maximum recommended weight limit for the Pediatric Triple Action is fifty kilograms, or one hundred and ten pounds. In some cases, the component may be appropriate for a heavier patient depending on their spasticity and activity levels.

Please contact a Becker Orthopedic customer service representative for assistance with these clinical applications.

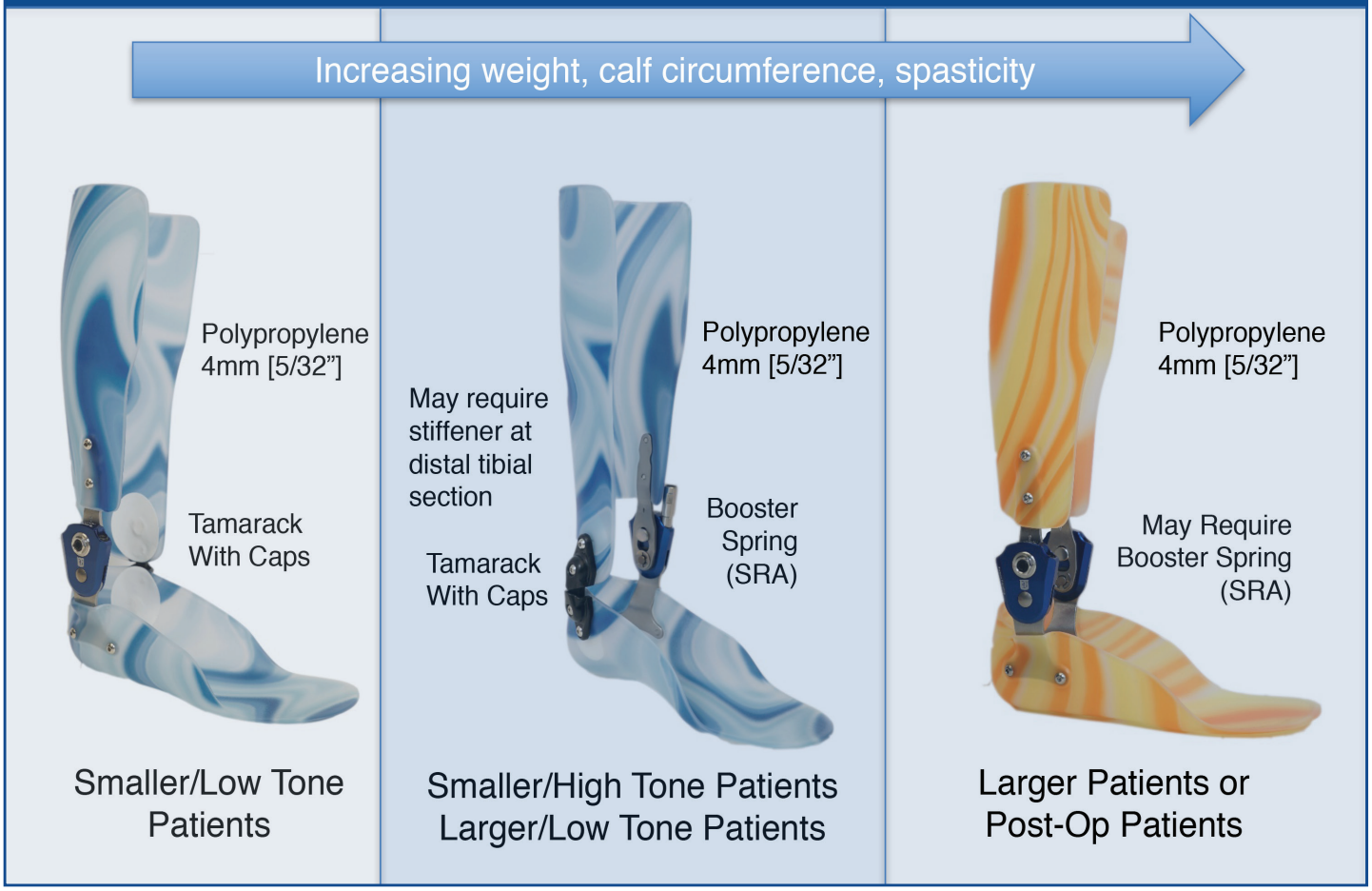
One Triple Action® or Two?



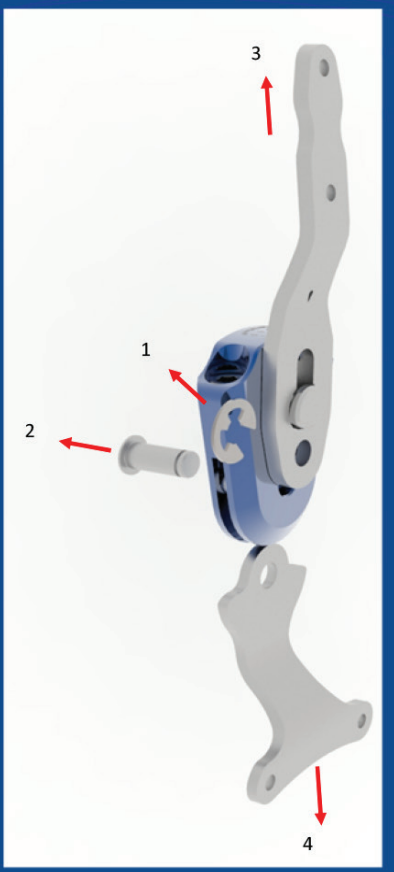
Two Triple Action components are recommended for Post-Op Applications

As patient weight, calf circumference and spasticity increase, additional spring force and shell stiffness are required.

Triple Action® AFO Design



This illustration summarizes the general recommended starting point for Triple Action AFO designs. Four millimeter (5/32 inches) thickness polypropylene is recommended for pediatric Triple Action AFOs. This thickness may be reduced for some designs by using stiffeners to enhance rigidity. If a single Triple Action is used, stiffeners may be required for moderate size, or spastic patients. Stiffeners placed at the distal aspect of the calf section are effective to increase the rigidity of the orthotic shell without negatively impacting the fit of the shoe. Using two Triple Action components will achieve maximum stiffness and will also provide the highest active resistance to ankle motion.



Fabrication

There are just a few special considerations when fabricating AFOs using the Triple Action ankle joint. The following section will provide the orthotist and technician with some useful tips.

Correct Cast to Management Angle

Correct the cast to the clinical management ankle angle prior to fabrication

Clinical Management Angle

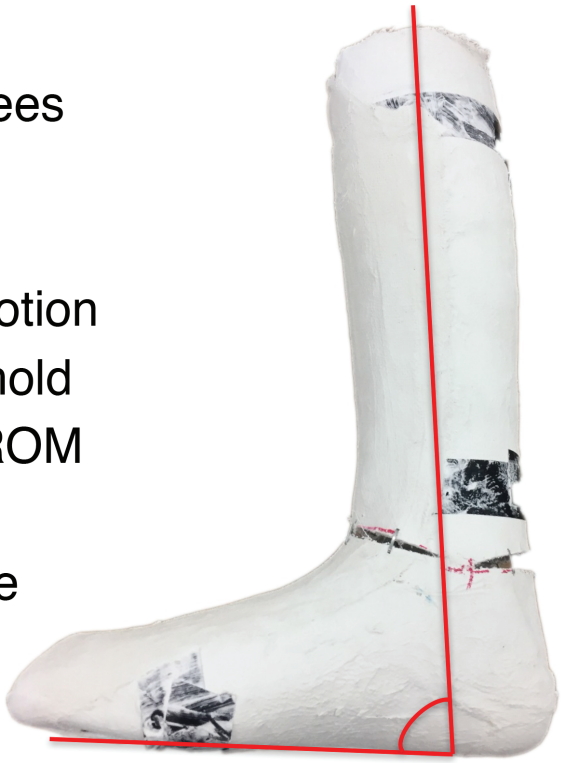
Prior to fabrication, the ankle angle of the mold should be corrected to the clinical management angle. This will determine the AFO footplate position when the Triple Action alignment setting is set to zero degrees.

Correct Cast to Management Angle

For Active Ambulators

This is typically 5 degrees dorsiflexion

If the patient's ankle motion is limited, correct the mold to the end of passive ROM in dorsiflexion (R2) evaluated with the knee extended



For active ambulators, the starting point for the clinical management angle should be set to five degrees of dorsiflexion. The patient's ankle should possess range of motion above and below this position.

If the patient's dorsiflexion range of motion is limited, correct the mold to the patient's maximum dorsiflexion angle at R2 (Tardieu), evaluated non weight bearing with the knee fully extended.

Please note that the orthosis or shoe may need to be posted to accommodate this ankle position with the shank inclined.

Correct Cast to Management Angle

For Contracture Management

Correct the cast to the maximum ankle angle anticipated after contracture management

If the AFO is to be used to manage a plantarflexion contracture, correct the mold to the dorsiflexion alignment anticipated at the end of contracture management.

Locate the Ankle Axis

Set the mechanical axis 13 to 25 mm [½ to 1 inch] proximal to the anatomical ankle axis.

This will position the stirrup above the collar of the shoe.

Set the alignment axis 13 – 25mm (1/2 – 1 ½ inches) proximal to the anatomical ankle axis. This will position the stirrup above the collar of the shoe.

Locate the Ankle Axis

Moving the Triple Action pivot proximal to the anatomical ankle axis will not significantly change movement between the AFO and the leg, but will dramatically improve fit to the shoe.

Relative movement between the leg and AFO for 15° ankle articulation	
AFO Axis Proximal to Ankle Axis mm[Inch]	Relative Movement AFO to Leg
13 mm [1/2 inch]	0.5 mm [.02 inch]
25 mm [1 inch]	1 mm [.04 inch]

Shifting the mechanical axis proximal to the anatomical axis will have minimal effect on relative movement between the orthosis and the patient's leg but will dramatically improve the fit of the shoe.

Locate the Ankle Axis

Lateral

Verify that the distal aspect of the lateral stirrup is positioned above the lateral tubercle of the heel and base of the 5th metatarsal.

Verify that the distal aspect of the lateral stirrup is above the lateral tubercle of the heel and base of the fifth metatarsal.

Position the Companion Joint

Medial

If using a medial Triple Action, verify that the distal aspect of the medial stirrup is plantar to the navicular.

If you are using a medial Triple Action component in your orthotic design, be sure to verify that the distal aspect of the medial stirrup is plantar to the navicular.

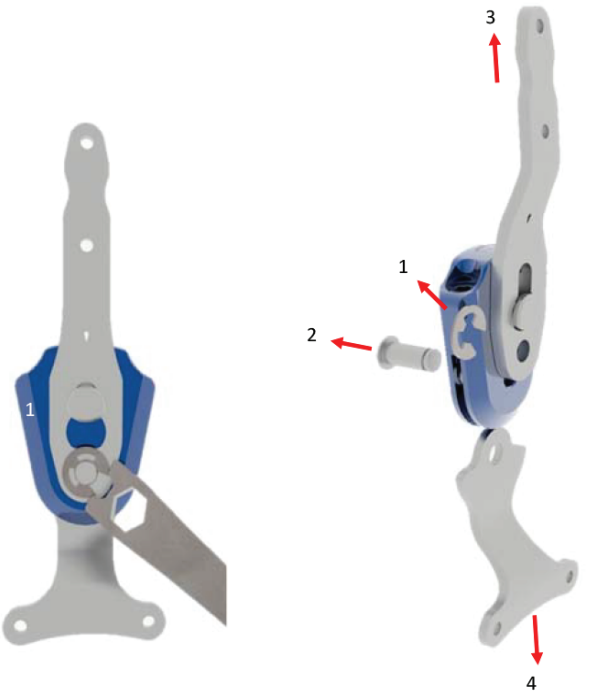
Set the Alignment Axis

- Place the Alignment Axis (included in the Fabrication Kit) in the negative mold
- Fill the mold
- Strip the mold
- Remove the Alignment Axis from the positive model

Drill a 9.5 mm (3/8 inch) diameter hole through the mold and insert the alignment axis. Fill and strip the mold and remove the alignment axis from the positive model.

Disassemble the Joint

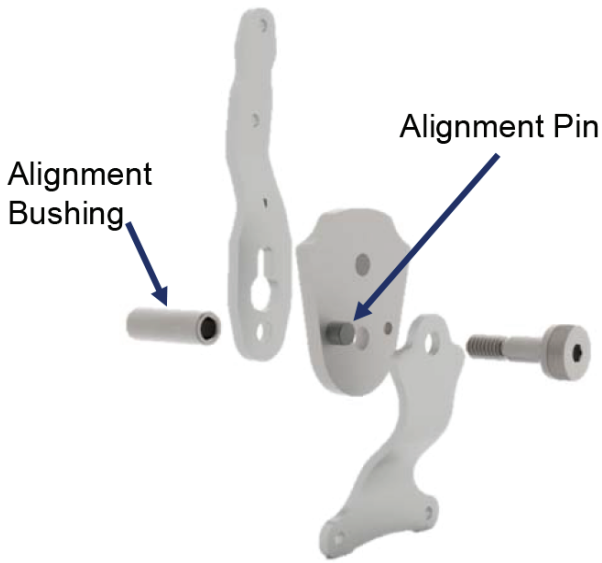
To assemble the fabrication tool, first remove the Upper Bar and Stirrup from the component body



The upper bar and stirrup must be removed from the component prior to assembling the fabrication tool for fabrication.

Assemble the Fabrication Tool

It's important to use the Fabrication Dummy to hold the Upper Bar and Stirrup in alignment during fabrication.



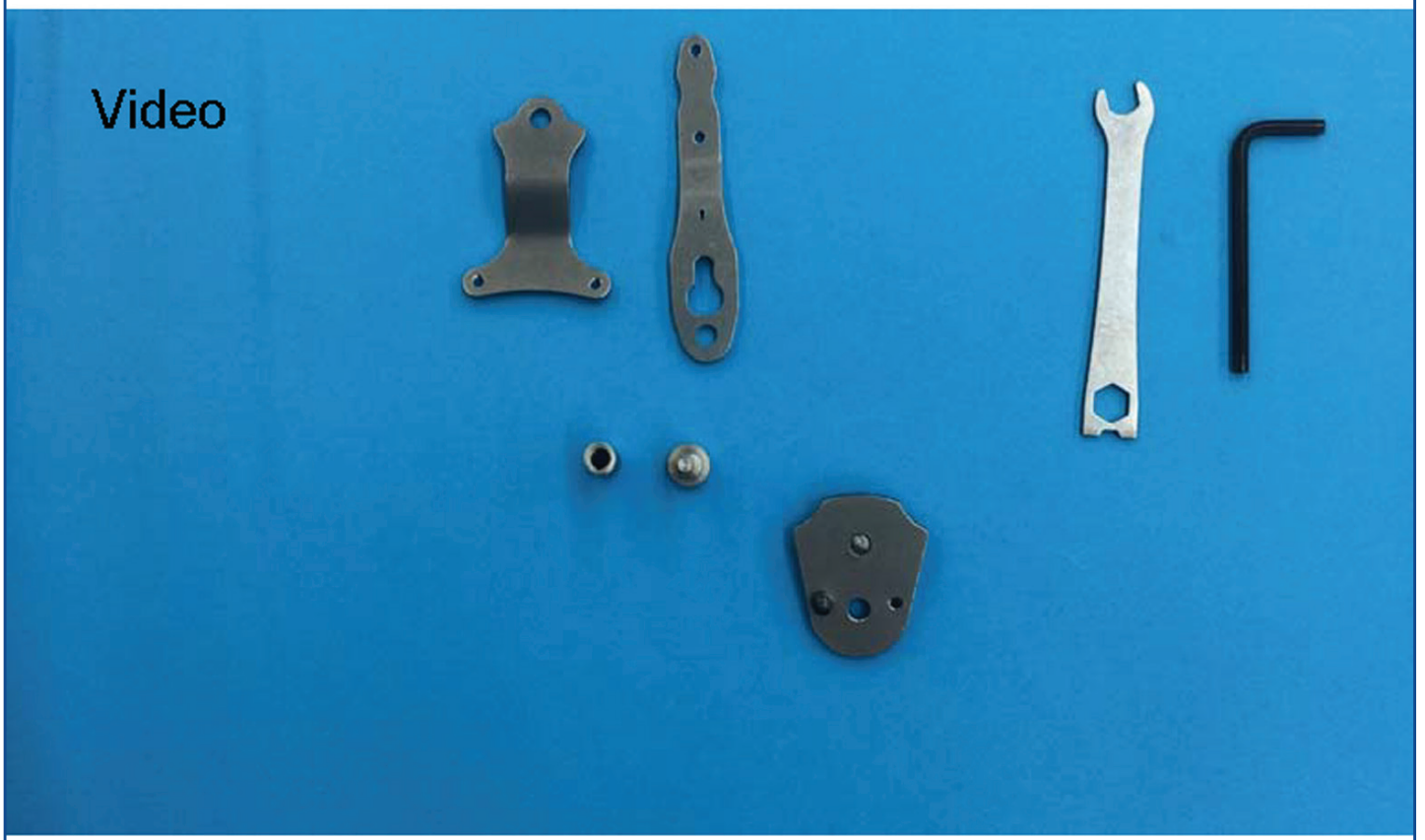
The fabrication dummy included with the fabrication kit holds the upper bar and stirrup in alignment during fabrication.

Disassemble the Joint

To disassemble the Triple Action component for fabrication, first slightly loosen the adjustment screws to reduce the pre-load of the springs on the stirrup head.

- Remove the E-clip using the included combination wrench.
- Remove the pivot bushing.
- Remove the stirrup and upper bar from the component body.

Assemble the Fabrication Tool



To assemble the fabrication tool:

- Correctly orient the stirrup and upper bar with the component dummy.
- Insert the shoulder screw through the pivot hole in the stirrup, dummy and upper bar, and attach the alignment bushing.
- Ensure that the stirrup head is seated firmly against the fabrication dummy alignment pin.
- Gently tighten the alignment bushing using the combination wrench and four millimeter hex wrench.

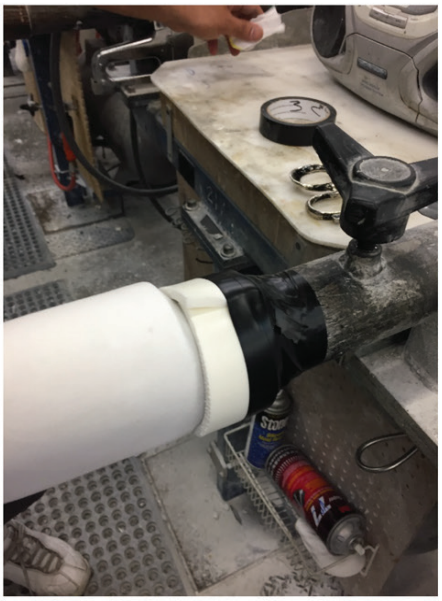
Contour the Bars

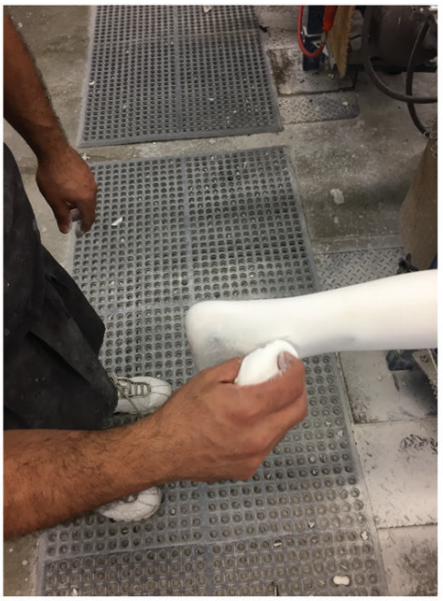
The Alignment Bushing fits into the Alignment Axis hole in the positive plaster mold during contouring

Important: Do not bend or mar the bars where they contact the component body

The alignment bushing fits into the hole in the mold formed by the alignment axis. It is important not to bend or mar the upper bar and stirrup where they contact the component. Doing so will damage the component.

Thermoform the Orthosis

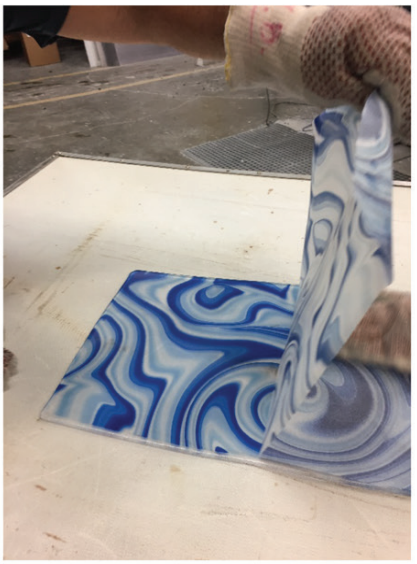




Prepare the mold for thermoforming. Use two layers of nylon stocking, cap the mold using polyethylene foam and talc the component.

Prepare the mold for thermoforming and lightly coat the component using talcum powder or corn starch.

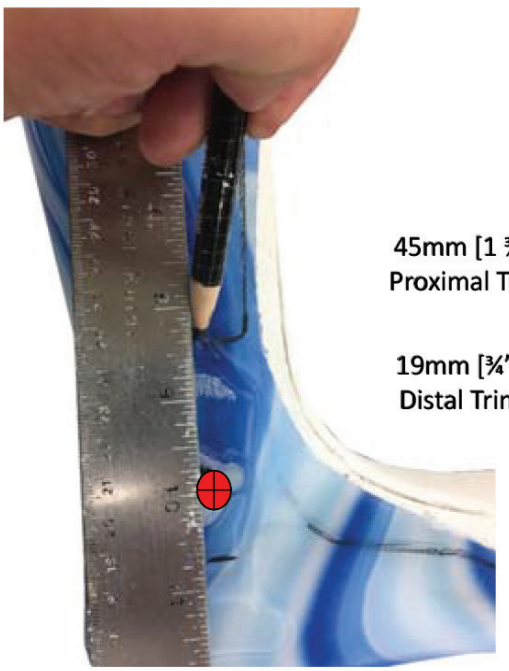
Thermoform the Orthosis

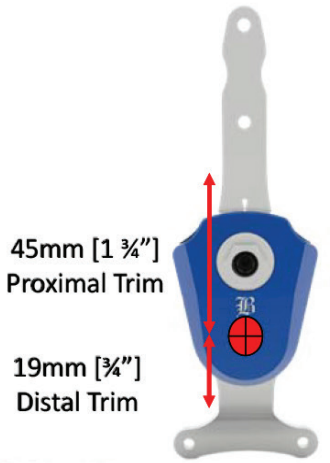


Heat 4mm (5/32 in) polypropylene sheet to 185°C (365°F). If a transfer pattern is used, spray the pattern with a silicone release lubricant. Transfer the pattern and thermoform.

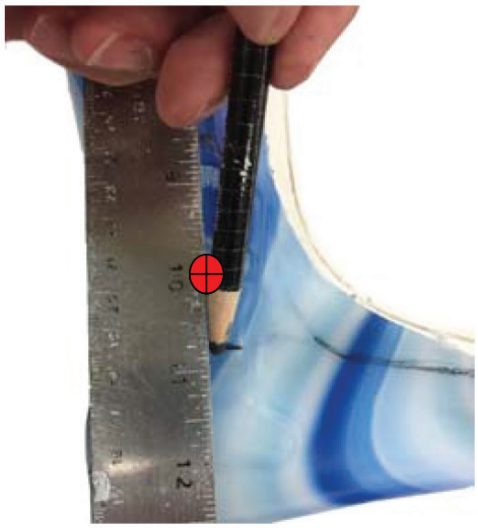
Heat the polypropylene sheet to a thermoforming temperature of one hundred eightyfive degrees Celcius, or three hundred sixty-five degrees Fahrenheit, to stress relieve the sheet. If using a transfer pattern, be sure to spray the film with a silicone release agent. Transfer the pattern and thermoform the orthosis.

Establish Trim Lines





The distal trim line is 19 mm [¾ inches] below the pivot bushing

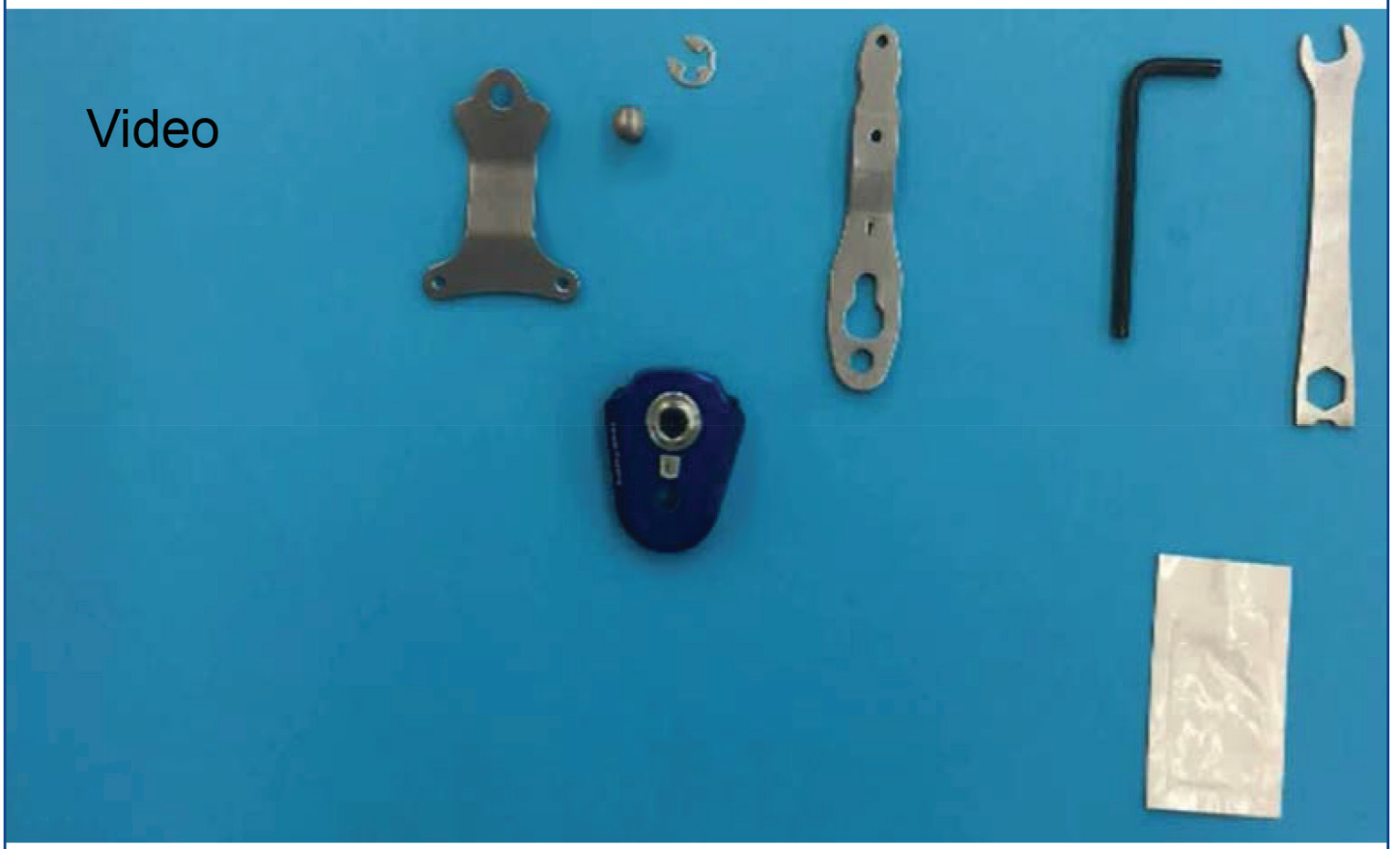


The proximal trim line is 45 mm [1 ¾ inches] above the pivot bushing

Draw the trim line 45 mm (1 ¾ inches) proximal to the joint center for the tibial section.

Draw the trim line 19 mm (3/4 inches) distal to the joint center on the footplate section.

Reassemble the Triple Action



Re-assemble the Triple Action.

- Apply Teflon grease to the stirrup and pivot bushing.
- Also apply grease to the keyhole shaped slot in the upper bar.
- Attach the upper bar to the component body.
- Insert the stirrup and install the pivot bushing.
- Finalize assembly by re-installing the E-clip.
- Lastly, verify that the component articulates freely after assembly.

Install the Companion Joint

Becker has validated the Tamarack Flexure joint with Caps (size medium) for some Single Component Pediatric Triple Action designs

If a free motion companion joint is used, install the joint on the medial side of the ankle. A good choice for a companion joint for the pediatric Triple Action is the medium size Tamarack Flexure Joint. The Tamarack, when installed using Tamarack Caps, has been validated through mechanical testing as a suitable companion joint for pediatric Triple Action AFOs.

Install the Companion Joint

Using Tamarack Caps

- Will maintain maximum plastic thickness during thermoforming
- Will reliably seat the Flexure Joint to minimize shear and rotation
- Will facilitate total contact of the medial footplate for optimal control

Tamarack Caps improve AFO stiffness and minimize joint motion while improving the control of total contact footplates.

Finalize Fabrication

Apply thread locker to all Bar Attachment Screws prior to delivery

Be sure to apply thread locking adhesive to all bar attachment screws to finalize fabrication.

Clinical Application

Tuning a Triple Action AFO is faster and easier than you may think. This section takes you step-by-step through the clinical application of a Triple Action AFO, including the tuning procedure to help you achieve the optimal outcome for your patient.

Triple Action® Tuning Procedure

The Triple Action Tuning procedure assists the clinician by:

- Defining explicit gait events for adjustment
- Defining a preliminary tuning methodology

The Triple Action tuning procedure focuses first on segmental kinematics, by defining specific events for observational gait analysis. The procedure is a useful starting point for a broad range of clinical applications.

Tuning Procedure Summary

Step 1. **Bench** Adjustment

Step 2. **Static** Alignment

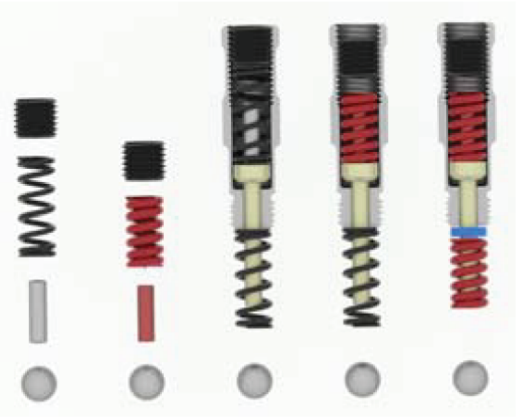
Step 3. **Swing** Phase Alignment

Step 4. **Stance** Phase Adjustment

This procedure consists of; Bench adjustment, static alignment, swing phase alignment and stance phase adjustment.

Tuning Procedure: Spring Selection

Note: Before performing Bench Adjustment, select and install the desired spring options.



Prior to beginning the tuning procedure, the appropriate spring configuration must be installed.

Tuning Procedure: Spring Selection

Note: Before performing Bench Adjustment, select and install the desired spring options.

Clinical Case Example:

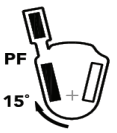
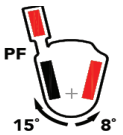
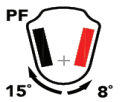
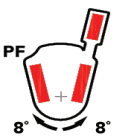
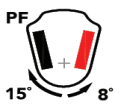
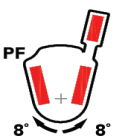
Assume that a patient presents clinically with a Hemiparetic CP Type 2 Gait: True Equinus (spasticity or contracture as opposed to flaccid foot drop in swing) with Knee Hyperextension.

Assume that the patient's weight is 30 kg (66 lbs) with high spasticity.

Reference: "Classification of gait patterns in spastic hemiplegia and spastic diplegia: a basis for a management algorithm". Rodda et al. 2001

For this example, let's assume that the patient presents with hemiparetic gait type 2 as defined by Rodda et al. This posture is described as true equinus with knee hyperextension. Let's also assume that the patient weighs 30 kg (65 lbs) and has high spasticity.

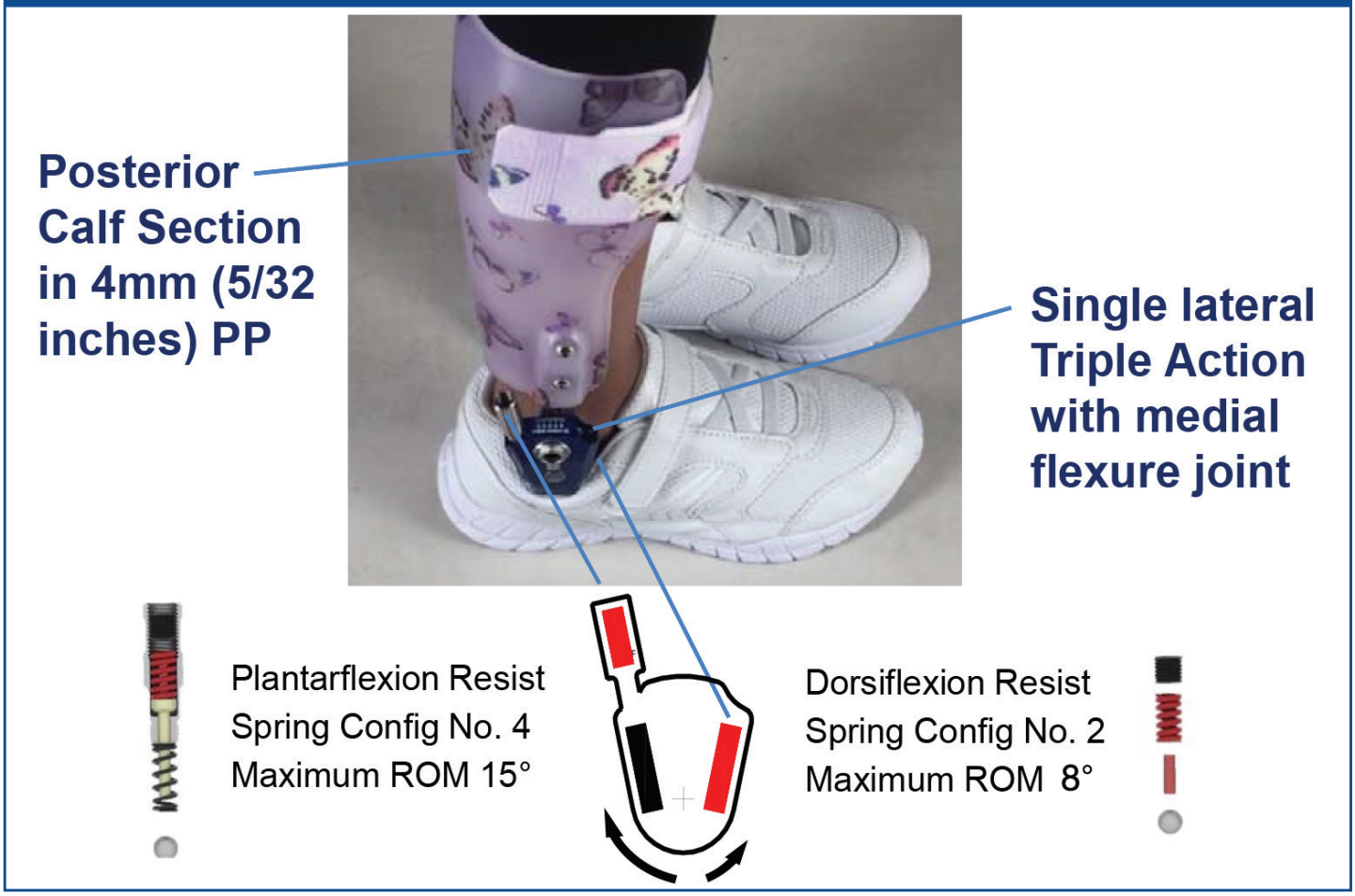
Tuning Procedure: Spring Selection

Gait Type*	Pattern	Orthotic Design	Mild to Moderate	Moderate to Severe
Gait Type 1: Hemiparesis with drop foot in swing phase secondary to dorsiflexion insufficiency. No significant triceps surae contracture.		Posterior (dorsal) tibial shell. Sulcus length footplate.		
Gait Type 2: Hemiparesis with dropfoot and true equinus secondary to triceps surae contracture, with or without genu recurvatum.		Posterior (dorsal) tibial shell. Sulcus length footplate.		
Gait Type 3: Hemiparesis with true equinus. Jump gait with contracture or spasticity of gastrosoleus. Spastic co-contraction of quadriceps and hamstrings.		Anterior (ventral) tibial shell. Full length footplate.		
Gait Type 4: Hemiparesis gait type 3 plus hip lexor/adductor spasticity.		Anterior (ventral) tibial shell. Full length footplate.		
Crouch Gait: Diplegia with excessive dorsiflexion, knee and hip flexion.		Anterior (ventral) tibial shell. Full length footplate.		

**Gait Type from "Classification of gait patterns in spastic hemiplegia and spastic diplegia: a basis for a management algorithm". Rodda et al. 2001.*

Becker Orthopedic provides general guidelines for the selection of the orthotic design for gait patterns in spastic cerebral palsy. These guidelines are intended to serve only as a starting point for the design of Triple Action AFOs. Based on these guidelines, the design of the Triple Action AFO for this patient would be a dorsal i.e. posterior calf section with a sulcus length footplate. A single Triple Action ankle joint would be used with a Booster Spring SRA.

Tuning Procedure: Design Summary



This slide summarizes the features of this particular AFO design. The orthosis would be fabricated using 4 mm (5/32 inches) thick polypropylene sheet. The Triple Action component would be mounted on the lateral side of the AFO and paired with a medium size Tamarack Flexure Joint with Caps on the medial side. The joint axis would be mechanically aligned, but shifted 13 mm (1/2 inches) proximal to the apex of the lateral malleolus. The Triple Action would be configured with Booster Spring No. 4 in the plantarflexion channel and spring No. 2 in the anterior channel.

Install the High Resist Spring

This video illustrates installation of the high resistance spring configuration No. 2.

- First remove the standard resistance spring and motion limiter pin from the component body.
- Use the grease included with the component to lubricate the red motion limiter pin and insert the pin into the red high resist spring.
- Wipe the excess grease from the outside of the spring.
- Insert the ball bearing, spring with motion limiter pin and adjustment screw back in the spring channel to complete installation.

Install the Booster Spring SRA

This video illustrates the installation of Booster Spring configuration No. 4. The Booster Spring comes with the red high resist spring and motion limiter pin preinstalled.

- Use the included grease to lubricate the Booster Spring pin and then insert the pin through the standard resist spring.
- Wipe the excess grease from the outside of the spring.
- Apply a small drop of thread locker on the SRA.
- Insert the ball bearing and Booster Spring in the spring channel and gently tighten using the combination wrench.

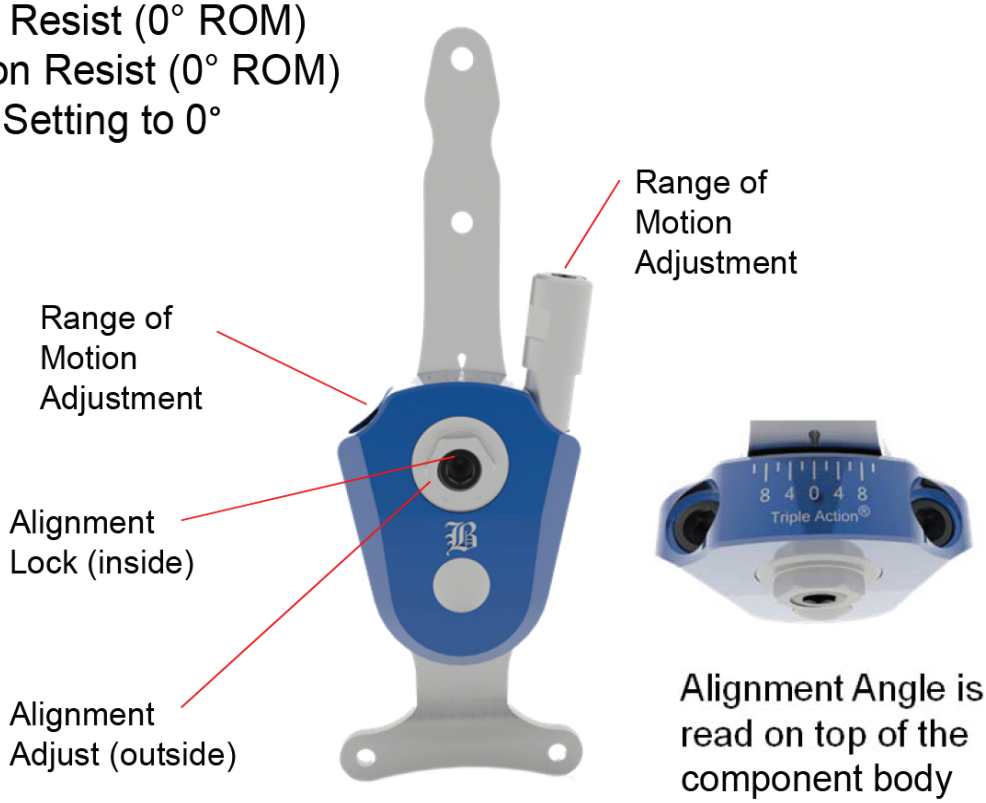
Tuning Procedure: Bench Adjustment

1. *Bench* Adjustment

The first step of the Triple Action tuning procedure is bench adjustment of the AFO.

Tuning Procedure: Bench Adjustment

- Lock Dorsiflexion Resist (0° ROM)
- Lock Plantarflexion Resist (0° ROM)
- Adjust Alignment Setting to 0°



To bench adjust the AFO, first reduce the range of motion in dorsiflexion and plantarflexion to zero degrees by turning the adjustment screws fully clockwise. Adjust the alignment setting to zero degrees.

Tuning Procedure: Bench Adjustment

1. Lock Dorsiflexion Resist 0°ROM
2. Lock Plantarflexion Resist 0° ROM
3. Set alignment to 0°
   - Loosen the Alignment Lock ½ turn
   - Adjust the Alignment to 0° This will be the fabrication angle
   - Lock the Alignment by tightening the Alignment Lock Screw

This video illustrates the bench adjustment procedure. Bench adjustment locks the AFO and positions the ankle angle at the clinical management angle.

Tuning Procedure: Static Alignment

1. ***Bench*** Adjustment
2. ***Static*** Alignment for Balance and Stability

The second step of the Triple Action tuning procedure is static alignment.

Tuning Procedure: Static Alignment

Don the orthosis and shoes to the patient

Adjust the shank to vertical angle (SVA) using the Alignment Adjustment

A typical starting point for the SVA is 11°

Don the AFO and shoes. With the patient standing, use the Triple Action alignment setting to tune the shank to vertical angle. A convenient way to measure the shank to vertical angle is to place an angle finder, or smartphone against the tibial crest. The typical starting point for shank to vertical angle is 11°.

Tuning Procedure: Static Alignment

This video illustrates static alignment.

Tuning Procedure: Static Alignment

Optimize the patient's sense of standing balance and stability.

If there is insufficient dorsiflexion ROM to make the adjustment due to a gastrosoleus contracture, a lift may be required under the heel of the AFO to incline the shank.

During this procedure, optimize the patient's sense of balance and stability using subjective feedback and objective observation. If there is insufficient dorsiflexion range of motion to achieve stability, it may be necessary to lift the heel of the AFO in the shoe to incline the shank.

Tuning Procedure: Swing Phase

1. ***Bench*** Adjustment
2. ***Static*** Alignment for Balance and Stability
3. ***Swing*** Phase Alignment for Toe Clearance and Foot Position

The third step of the Triple Action tuning procedure is swing phase alignment.

Tuning Procedure: Swing Phase

- With the patient walking and the component ROM still 0°, adjust alignment to optimize toe clearance in mid swing and foot position at initial contact.
- Note that increasing dorsiflexion alignment may reduce knee extension at terminal swing if there is gastrocnemius tone or contracture.
- Also observe step length symmetry while making this adjustment.

Toe clearance (left) and Foot to Floor Angle (right)

With the patient walking and the range of motion of the Triple Action component still locked at 0°, observe toe clearance in mid swing and the angle between the sole of the shoe and the floor. Use the alignment setting to optimize these two gait events.

Please note that if there is insufficient range of motion, or high tone in the gastrocnemius, increasing dorsiflexion alignment may reduce knee extension at terminal swing and decrease the foot to floor angle at initial contact.

Observe step length symmetry by gauging the position of the heel with respect to the contralateral toe during this adjustment.

Tuning Procedure: Early Stance

1. ***Bench*** Adjustment
2. ***Static*** Alignment for Balance and Stability
3. ***Swing*** Phase Alignment for Toe Clearance and Foot Position
4. ***Stance*** Phase Adjustment for:
   - Knee Stability in Early Stance
   - Knee Stability in Late Stance

The last step of the Triple Action tuning procedure is stance phase adjustment. This step involves mobilization of the ankle first in early and then in late stance.

The Triple Action plantarflexion resist function has been shown to systematically influence the swing and early stance phases of gait, while the Triple Action dorsiflexion resist function has been shown to influence ankle and knee stability after mid stance.

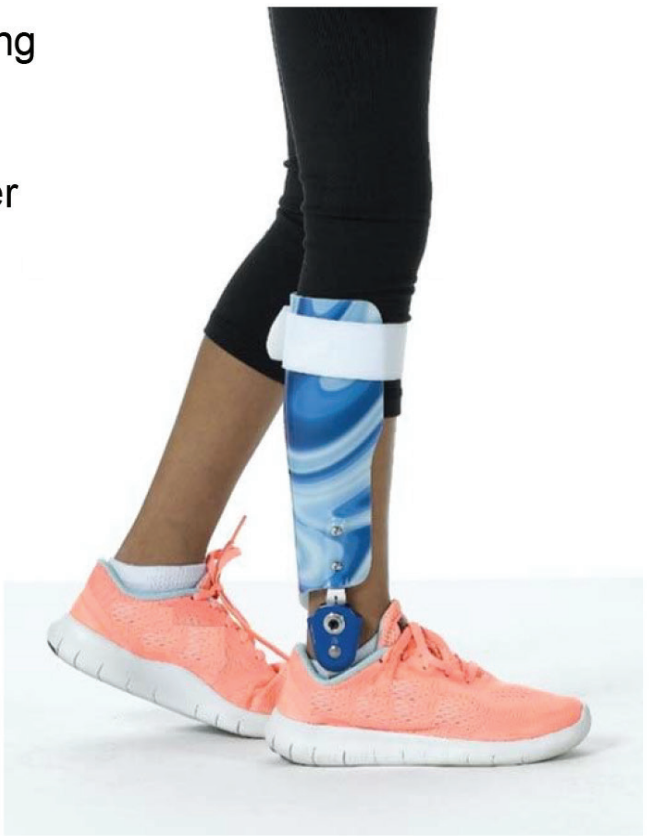
The influence of these functions may be effected by the nature of the patient's biomechanical deficits.

Tuning Procedure: Early Stance

Increase the plantarflexion ROM setting by 1 to 2 turns (5° - 10°)

This will activate the ankle in 1st rocker and early stance to stabilize the knee

Dorsiflexion ROM will remain at 0° during this procedure



Early stance phase adjustment is performed with the patient walking. Begin this adjustment by mobilizing the first rocker. Increase the plantarflexion resist range of motion 5 – 10°. Dorsiflexion resist range of motion will remain locked during this early stance phase adjustment.

Tuning Procedure: Early Stance

This video illustrates adjustment of the plantarflexion range of motion to 5° by turning the adjustment screw one turn counter clockwise.

Tuning Procedure: Early Stance

If toe clearance or foot to floor angle decreases ⇒ Decrease Plantarflexion ROM

If knee hyperextension in early stance increases ⇒ Decrease Plantarflexion ROM

If knee flexion is excessive in 1st rocker ⇒ Increase Plantarflexion ROM

Dorsiflexion Resist Locked

Observe toe clearance in mid swing, as well as foot to floor angle at initial contact. If either of these measures decreases with the increase of plantarflexion range of motion, decrease the plantarflexion range of motion by turning the adjustment screw clockwise. Observe knee extension after loading response and before mid stance. If the knee hyper extends with the increase in plantarflexion range of motion, decrease the plantarflexion range of motion by turning the adjustment screw clockwise.

If the plantarflexion range of motion must be set to less than five degrees to actively manage the position of the ankle or the stability of the knee, it may be necessary to increase the resistance of the plantarflexion spring by changing the spring configuration. However, the passive range of motion of the ankle in dorsiflexion as relates to ankle alignment should also be considered. Observe knee flexion in first rocker. If the knee flexion is excessive, increase the plantarflexion range of motion by turning the adjustment screw counter clockwise. Remember to count the number of turns of the adjustment screw to keep track of the range of motion setting.

Tuning Procedure: Late Stance

1. ***Bench*** Adjustment
2. ***Static*** Alignment for Balance and Stability
3. ***Swing*** Phase Alignment for Toe Clearance and Foot Position
4. ***Stance*** Phase Adjustment for:
   - Knee Stability in Early Stance
   - Knee Stability in Late Stance

The last step of the tuning procedure is the adjustment of the dorsiflexion range of motion to tune knee stability in late stance phase.

Tuning Procedure: Late Stance

Increase the dorsiflexion ROM setting by 1 to 2 turns (5° - 10°)

This will activate the ankle in 2nd rocker to help stabilize the knee

Late stance phase adjustment is performed with the patient walking. Begin by mobilizing the ankle in second rocker by increasing the dorsiflexion range of motion five to ten degrees.

Tuning Procedure: Late Stance

This video illustrates adjustment of dorsiflexion range of motion to seven and a half degrees by turning the adjustment screw one and a half times counter clockwise.

Tuning Procedure: Late Stance

If knee flexion is excessive after mid stance ⇒ Decrease Dorsiflexion ROM

If the knee hyperextends at the end of stance phase ⇒ Increase Dorsiflexion ROM

Observe knee flexion after mid stance. If knee flexion is excessive, decrease dorsiflexion range of motion by turning the adjustment screw clockwise.

If the range of motion setting must be set to less than five degrees to actively manage the ankle or the stability of the knee, it may be desirable to increase the resistance of the dorsiflexion resist by changing the spring configuration.

Observe knee extension after mid stance. If knee extension is excessive, increase dorsiflexion range of motion by turning the adjustment screw counter clockwise.

Remember to count the number of turns of the adjustment screw to keep track of the range of motion setting.

Tuning Procedure: Final Tuning

Additional fine tuning may be necessary to achieve optimal results.
Observe:

- ✓ Patient feedback/comfort
- ✓ Gross trunk motion
- ✓ Upper and lower extremities
- ✓ Step width variability
- ✓ Step length variability

This completes the preliminary Triple Action tuning procedure. Additional fine tuning may be necessary to achieve optimal results. Guiding the patient toward comfort, stability and a sense of improved function in the short and long term is a critical aspect of orthotic optimization. Solicit the patient's feedback regarding their sense of stability and comfort.

Observe whole body, rather than segmental kinematics. Other objective clinical signs that may be useful for component optimization include: gross trunk motion, position of the upper extremities, step width variability as an indication of lateral balance and step length symmetry and variability as an indication of stability.

Tuning Procedure: Prior to Delivery

- If two Triple Action components are used on the AFO, match settings
- Torque the Alignment Lock to 15 Nm before delivery
- Chart
  - ✓ Spring Configuration Number
  - ✓ ROM Setting
  - ✓ Alignment Setting

Prior to delivery of the AFO, ensure that the medial and lateral component settings on bilateral Triple Action AFOs are the same. Torque the alignment lock to 15 Nm and chart:

1. Spring configurations
2. Range of motion
3. Alignment settings

Triple Action® Summary

The Pediatric Triple Action ankle joint is a durable orthotic component, with exceptional adjustment capabilities for active support of the ankle and knee.

The component separates Resist, Range of Motion and Alignment for precise control of gait.

The Triple Action was designed to fit with pediatric clinical practice for:

- **Active Ambulators with complex, combined and/or changing neuromuscular deficits**
- **Contracture management**
- **Post Surgical patients**

The Pediatric Triple Action ankle joint is a durable orthotic component with a high range of adjustability for active management of the ankle and knee.

The component separates resist, range of motion and alignment functions to simplify tuning and make the effect of the component's systematic influence on gait more visible.

Triple Action AFOs find application in the full range of pediatric orthotic care, including support for active ambulators, static progressive contracture management and postsurgical management.

Triple Action® Summary

Triple Action Orthotics can impact your clinical practice by providing:

- **A treatment algorithm to simplify and standardize the delivery of orthotic care for complex patients**
- **Settings that can be used to track patient progress**
- **Enhanced documentation for reimbursement**
- **Features that can positively impact collaboration with physical therapy and other health care services**

Triple Action orthoses can impact your clinical practice by providing a treatment program to help standardize and optimize the delivery of pediatric orthotic care, document patient progress and create opportunities for collaboration with other allied health care professionals.

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