Fabricating for Tone Reduction

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What Is Tone?

- Tone literally means activation of a muscle.
- Spasticity is derived from the Greek word meaning to pull or draw.

The word tone is used literally to mean the activation of a muscle. This can refer to controlled or uncontrolled firings so we additionally apply the word spasticity to this condition. Spasticity is derived from the Greek word meaning to pull or draw and in this context refers to a sudden involuntary contraction of a muscle.

What does all this mean to us? Simply, it means a fundamental shift in the way we see the devices we produce. For years we have been taught to use the three point pressure system to model the patients bony prominences into position. With tone reduction techniques we are using deep soft tissue pressure to reduce the patients “spastic response”. In order to do this we will need to look more at the hidden skeletal structure and produce vastly more anatomically accurate models.

There is, of course some debate over the efficacy of this technology. Does it work because of the neurological response or is it simply accurate skeletal manipulation? So far we have evidence to support both theories, so more research is needed. Ultimately the important factor is function, and properly fabricated these devices function very well.

Cast Correction:

- Cast may require greater than normal correction
- Make sure to correct cast at the articulating surfaces

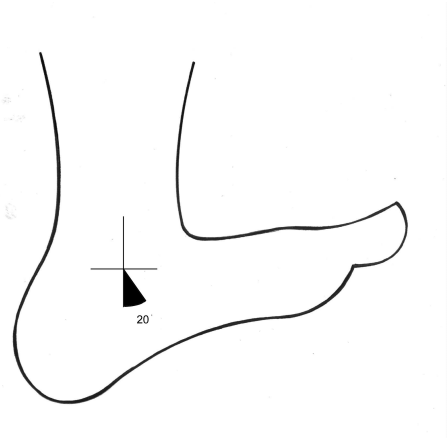
The first place the technician comes in contact with tone reduction is in the cast correction phase of production. We usually attempt to correct every cast to production quality, but with the relative precision needed to produce these sensitive devices we need to make sure the cast is as close to the desired end result as possible.

Also, because of the spastic nature of the patients, the casts may be farther than normal from the desired position. As a rule I recommend that the practitioner do everything possible to maintain sub-talar neutral and not be overly concerned with dorsiflexion. Correcting the df/pf angle is very easy, but if you collapse the mid foot by forcing the patient into “dorsiflexion” you will never achieve a functional device.

It is important when correcting a cast to make sure corrections are made at the articular surfaces! You have to know how and where the bones move in relation to each other. You should study skeletal charts and diagrams very carefully to ensure the accuracy of your modifications.

Dorsiflexion Angle

- Maximum dorsiflexion deviation should be no more than 20 degrees.
- Watch for cavus arch !



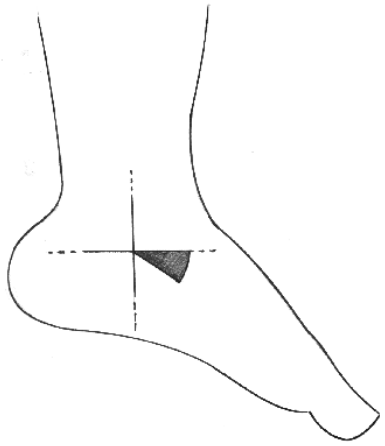
First you should carefully examine the cast for dorsiflexion anomalies. Excessive dorsiflexion is common in the initial cast and needs to be carefully corrected to the practitioners specified angle. If the angle presented is greater than twenty degrees from the desired end result you may have some difficulty in achieving an accurate fit, and I would recommend a recast.

If a recast is not possible then you should carefully split and articulate the cast. It may be necessary to slide the tibial section anterior on the foot portion to correctly align the too halves. This radical a procedure rarely produces optimal results but carefully completed, an acceptable orthosis can still be produced.

One potential problem in assessing the dorsiflexion angle is the cavus arch deformity. This deformity will make the cast appear to be in neutral when the hind foot may still be in significant dorsiflexion. If the patient presents with a cavus arch you will need to discuss the treatment options very carefully with the attending practitioner.

Plantarflexion Angle

- Plantarflexion angle should be no more than forty degrees.
- Watch for plantarflexed metatarsals



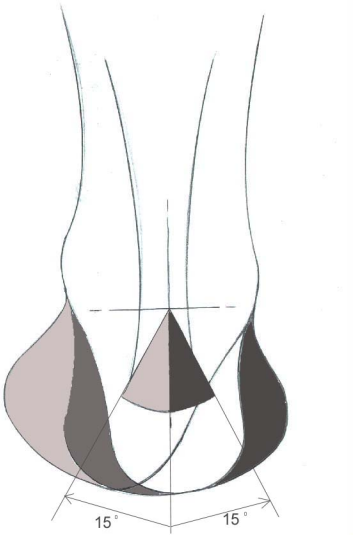
The most common cast anomaly presented in the casts for tone reducing orthoses is the hyper-plantarflexion. Because the most common and most visible spastic response is a plantarflexion response it is very common for the patient to spasm into plantarflexion during casting. Fortunately this anomaly is easy to rectify.

Plantarflexion like any anomaly has an acceptable range. I have found that plantarflexion greater than forty degrees will result in less than optimal results and recasting may be warranted. If this is not possible then you should be careful to shift the calf section posteriorly in relation to the foot section to compensate for this extreme alteration.

One common mistake in cast correction is misreading plantarflexed metatarsals as talo-calcaneal plantarflexion. You can easily asses the difference by hiding the fore foot and examining the hind foot, if the hind foot appears to be at neutral, the plantarflexion should be corrected at the mid foot. It is very important to make these corrections at the proper level or these orthoses will not fit.

Inversion/Eversion Angle

- +/- 15 degrees
- Cast corrections are difficult



Inversion/eversion disorders can be very difficult to asses and even more difficult to correct since almost all inversion/eversion misalignments are rotary in nature. At best you can only correct the uniplaner anomalies(talo-calcaneal inversion/eversion) in the negative mold. Once this has been done the remaining anomalies will have to be corrected in the positive model.

Excessive inversion will result in a prominent lateral maleoli and an adducted fore foot, excessive eversion will result in a prominent medial maleoli and an abducted fore foot. Both of these can be difficult to accurately correct. With practice and very good M.L. and circumference measurements at the ankle, mid foot, and fore foot these corrections can be made satisfactorily.

Mold Modification

- The model must accurately mimic the patients physiology
- You have to have intimate knowledge of skeletal structures!

These models more than any other we produce, must accurately mimic the patients natural physiology. Not only are the models generally quite small but the because of the intimate nature of their fit, precision is imperative.

You will have to have intimate knowledge of skeletal structures, the surrounding soft tissue, and even the Neuro-vascular systems of the foot. If this all sounds overwhelming do not worry, there are some very simple practices you can do to assist in your education. You can work with live patients, you can find some one friendly to palpate, and you can refer to charts and reference books.

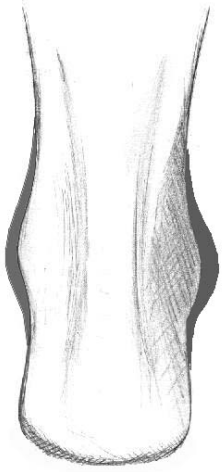
Because of the atypical structure of most of our patients feet the best exercise is to assist in the casting of as many patients as possible. At least several of each diagnosis will give you a good foundation. Then you should follow up on as many fittings as possible to see the outcomes of each job. I also recommend repeating the process every year or so.

Weather you have access to live patients or not you should find some one who will let you palpate their feet. Through this exercise you can ask questions about the pain threshold and see the relationship of the soft tissues to the bony structures. Your partner in this process would ideally be some one who can give you good feedback (preferably an adult).

You should also rely heavily on illustrated reference works on anatomy. These references are readily available at books stores or local libraries. Wall charts can be very helpful. I think one of the best exercises you can do is to practice drawing the bones of the foot from memory and then comparing them to reference sources.

Maleoli Buildups

- Buildups should be more "extreme" than usual
- Take into consideration varus valgus tendencies

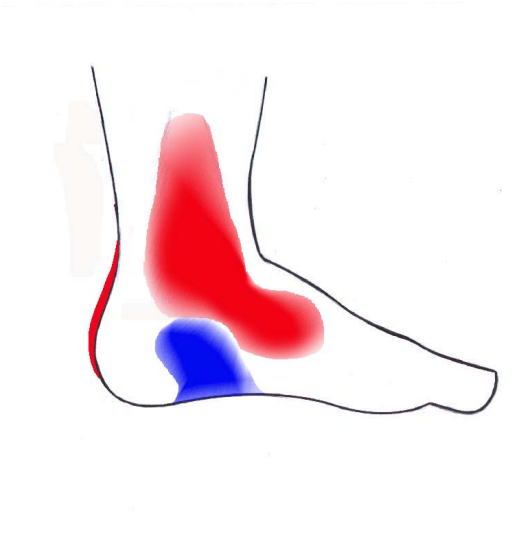


Maleoli buildups will as a rule appear more extreme than usual. This is due to the need to use the soft tissue immediately surrounding these bones to lock the talo-calcaneal joint in a fixed position. It helps to use nails to indicate the desired heights of these buildups.

Be sure to take into consideration the varus/valgus tendencies of each patient. If a patient tends to go into a varus position you may want to allow more relief at the lateral maleoli and if the patient exhibits a valgus tendency more relief at the medial maleoli may be warranted. Remember to only relieve the bony prominence, as it will be more important than ever to make use of the surrounding soft tissue to model the patient into the correct position.

Medial Maleoli/Navicular

- Two apexes
- Blend well into surrounding soft tissue



Often one of the more complex areas of relief will be the medial maleoli/navicular region. Many patients will get a great deal of pressure in this area unless properly relieved. It is important to see these prominences as two distinct apexes that blend together.

You should also remember to add pressure under the navicular and blend this area well into the surrounding plantar surfaces.

Calcaneal Cuboid Buildup

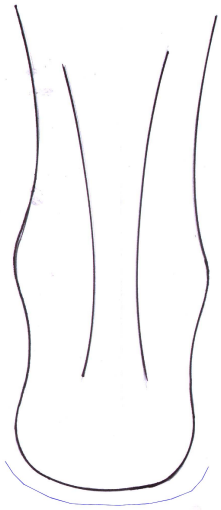
- Include achilles tendon extension
- Be sensitive to prominent heels

When relieving the calcaneal cuboid you should be careful to include some relief for the Achilles tendon. A tear drop shape works well and generally a few millimeters will suffice.

Some people prefer to actually add pressure to the insertion of the Achilles tendon. As a rule I do not recommend this because of the high incidence of tissue breakdown and the tendency to cause a planterflexion response.

Heel Buildup

- Heel should be rounded
- Heel should be symmetrical

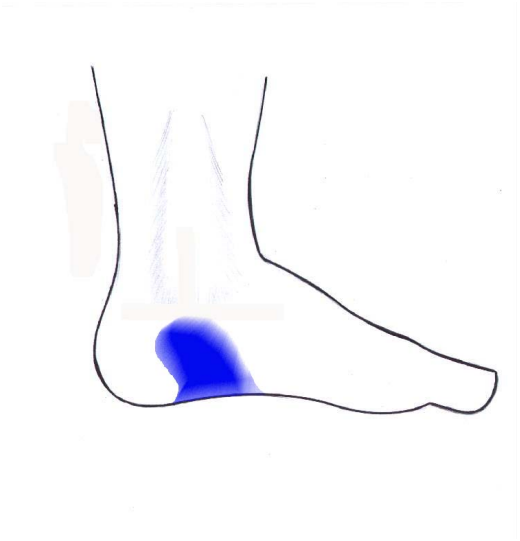


Contrary to common practice the heel of a tone reducing orthosis should be rounded, not flattened! For years we have been flattening the heels of our molds, and for many types of orthosis this is acceptable, however because of the need to lock the distal calcaneus in a neutral position this is contra-indicated in tone reducing orthoses. To stabilize the hind foot at heel strike you should instead use an extrinsic post.

It's also important to make sure that the heel shape is symmetrical. This will equally distribute pressure on both aspects of the heel, resulting in a more neutral tendency.

S.T. Groove

- Anatomy rules
- Blend into longitudinal arch

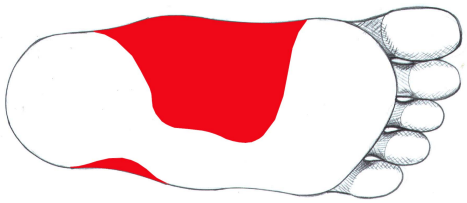


The sustentaculum-tali or S.T. for short refers to the area between the navicular, calcaneus, and talus. Properly exploited this area can be an excellent control site. To control internal rotary disorders, common to this patient population, a significant amount of material will have to be removed to make contact with this area. So it is very important to maintain an anatomical shape, this will require intimate knowledge of the bony structures of the foot.

Once the proper depth is achieved you should blend the groove into the surrounding surface very gradually. Focusing to much pressure in this area will result in tissue breakdown.

Medial/Lateral Arches

- Smooth transition
- Connect around to plantar surface of calcaneus

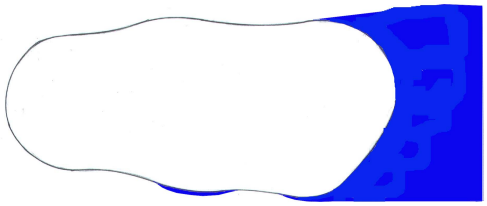


The most important things to remember when carving the longitudinal and lateral arches are to maintain the natural shape of the arches and to use the soft tissue to maximize load bearing. The soft tissue of the plantar surface of the foot is fairly evenly distributed throughout the arch. Using this tissue will allow for a naturally padded surface to manipulate the cuneiform and the metatarsals into a neutral position.

When making this modification be sure to blend the arches back into the fatty pad surrounding the calcaneus.

Cuboid/ Lateral Fifth Met Head

- Relieve 1.5-3.0 mm
- Be careful to maintain radius of plantar lateral surfaces

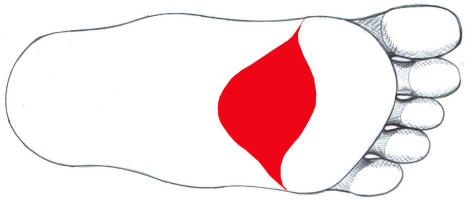


The bony prominences along the lateral borders of the foot can be very problematic due to their relatively thin covering of skin. I recommend buildups of 1.5mm to 3.0mm depending on the size of the patient.

Remember to continue your buildup around to the planter surface of the mold slightly.

Metatarsal Relief

- Proximal edge relief
- Distal edge relief



The proximal metatarsal relief is one of the most hotly contested areas of mold modification. Personally I use a very naturally shaped met pad that extends all the way across the foot to include the first and fifth metatarsal heads. The depth of the cut away is relative to the patient and the required amount of relief.

I rarely include the distal metatarsal relief in the mold. Preferring rather to use a foam toe extension pad that can be glued into the orthosis at the fitting. This allows for maximum adjustability as well as some room for growth.

Padding Techniques

- Bony prominences only
- Blend edges smoothly
- Colored foams

Comfort is a function of the shape of the orthosis, not the padding used. Still in order to assure the maximum performance of the orthosis it may be wise to pad the bony prominence with a dense foam padding. If you find yourself using thicker softer padding to reduce pressure it should be an indicator that your mold shape is not effective and you should seriously critique your modifications.

Whatever padding you use be sure to blend the edges of the pads to a very smooth transition. Unblended edges are a frequent source of irritation and breakdown. This easy to fix problem can often spoil an otherwise fine orthosis.

I like to use colored foams whenever possible to enhance the visual impact of the orthosis. Even if you don't want to stock a lot of different colors, just primary red, yellow, and blue can go a long way.

Material Selection

- Polypropylene
- Polyethylene
- Copolymer

The three most popular materials for use in these devices are polypropylene, polyethylene, and copolymer. The varying densities of these materials can offer a wide window of possible functions to the technician. Choosing the correct material for a particular job can be tricky but a few guidelines should help significantly.

As a rule most of the devices we make are polypro. It allows the rigidity we need with a very thin cross section. Of course this material can be difficult to modify in these thin gauges and in very cold climates can tend to crack. It is also sometimes subject to break if subjected to sharp impacts.

Copoly is a good material for articulating orthoses. It is tough, easy to modify and exhibits good post molding stability. Problems with this material include a lack of rigidity, a tendency to whiten at high stress areas and cold forging (plastic deformation resulting from constant bending). Thicker gauges can be quite rigid for use in cold climates but even though they may not break like polypro they may eventually bend out of shape.

Polyethylene is very flexible and easy to modify and therefore ideally suited to orthoses for non-ambulatory patients and for the inner boot of the two piece orthoses.Its primary weakness is also its flexibility. It is not recommended for solid ankle orthoses or any design which will require constant bending (although toughened formulas like modified polyethylene are very strong).

Pulling Plastic

- Focused stretch
- Proper temperature
- Maximum vacuum

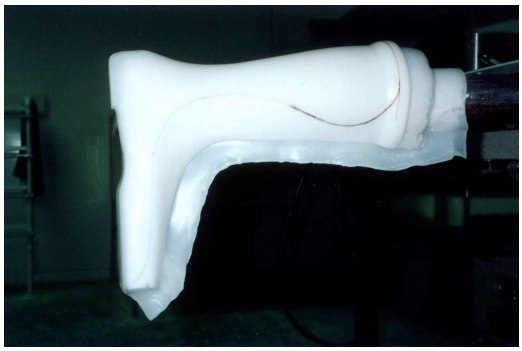
One of the most complex facets of producing tone reducing designs is forming the plastic to accomplish total contact. The finished product must be free of wrinkles, very thin across the dorsum of the foot to allow for easy donning and still maintain the correct level of rigidity at the posterior and plantar surfaces. Developing the technique to properly accomplish all these goals can take some time but is well worth the effort.

Developing the proper temperature requires a good knowledge of your oven and good timing. Every oven heats with a different pattern and at different speeds. I recommend infrared ovens when using these thin gauges of material because they exhibit good uniformity and heat very quickly.

You will also need good solid vacuum with a sustainable source. We use venturi pumps because they allow for about three times the C.F.M. rate of rotary vane pumps. This allows for a very fast recovery of the pressures lost upon opening the valve to initiate suction.

Trimming Plastic

- Establish trim lines
- Poly posting is ground first
- Trim lines must be smooth



Once the material has been formed,and has cooled to below the workable thresh hold (190 degrees)you can apply trim lines. Establishing these trim lines can be critical to the function of the device so input from the practitioner is essential. We suggest the practitioner draw the desired lines on the outside of the negative mold, these lines are then transposed to the finished product.

Before removing the plastic from the mold the polymer posting is ground to near net shape. If you use polymer posting this can greatly increase the success rate. Frequently the minor amount of shrinkage in the de-molded product can cause the two pieces of plastic to delaminate thus ruining the work piece.

When drawing and grinding trim lines they should always be very smooth and free of facets and sharp edges. Tremendous amounts of pressure will be generated at the edges of these devices and the patients extremity will be constantly moving against the edge surfaces. A great deal of unnecessary tissue break down can be avoided by simply polishing the edge surfaces carefully before delivery and after any modifications are made.

Finishing & Decorating

- Colored Velcro
- Foams
- Ribbon
- Transfers

The majority of the devices we fabricate with these techniques are for pediatric patients, so we take extra care to increase the visual appeal of each orthosis. Without the ability to fully comprehend the physiological benefits of the brace many patients will reject the device. By increasing the visual appeal we make the device easier to accept. It takes very little extra effort to turn the orthosis into a toy, increasing the acceptance by the patients as well as their parents and peers.

The easiest way to dress up an orthosis is to apply colored Velcro. Readily available from most industry suppliers, this material can go a long way to increasing the visual appeal of an other wise sterile device.

Colored foams are becoming very popular. Available from a number of German based suppliers with American distribution points, foams can be slightly expensive to stock in great variety but if you stick to the primary colors they are not much more expensive than the equivalent foams in white or beige.

We also choose to stock a number of commercially available ribbons which we apply to the Velcro straps. This is just one more way to increase the desirability of the finished product.

Additionally we offer a variety of transfers which can be applied to the plastic during the forming process. This has become a very popular option, allowing the patient to customize their orthosis with a great number of cartoon characters, sports logos, and even appealing patterns.

For additional information on this

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