

COMPLICATIONS OF BRACHYMETATARSIA REPAIR WITH CALLUS DISTRACTION

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INTRODUCTION

Brachymetatarsia represents one of the best and most useful indications for callus distraction in the foot.¹ The author believes callus distraction offers many advantages over other techniques for surgical correction of brachymetatarsia. Technically, the procedure is easier than procurement and placement of bone graft or complex lengthening osteotomies. Also, correction is closely monitored and achieved over time. The surgeon slowly obtains correction through a gradual process as opposed to being restricted to the degree of correction achieved at the time of surgery. Therefore, he or she can modify the amount of correction needed by lengthening more and possibly shortening slightly if over lengthened. This gradual lengthening process provides sufficient time for the soft tissues to slowly adapt; therefore, the chances of vascular insult are greatly decreased for callus distraction when compared with other procedures, since immediate, abrupt lengthening of the vasculature is avoided. It is because of these advantages and many other aspects unique to callus distraction that the author favors this surgical technique for brachymetatarsia repair.

Although callus distraction has many advantages over other techniques for brachymetatarsia repair, it is not without its limitations. The postoperative course is rigorous and demanding on both the surgeon and the patient. Also, the success of this procedure is highly dependent upon patient compliance and the patient understanding the importance of their compliance. Due to the intense patient involvement postoperatively, this is not the procedure of choice for a potentially noncompliant patient. Careful patient selection is of the utmost importance when choosing this procedure for repair of brachymetatarsia.

Patient education is one of the keys to a successful surgical result for brachymetatarsia repair with callus distraction. All relevant deformities, the amount of correction that can be obtained, the possible complications, and the intense postoperative course with which the patient will be intimately involved should be thoroughly discussed with the patient preoperatively. If the patient does not seem to comprehend the extent of their involvement postoperatively or understand that a postoperative complication

can occur and is not uncommon, they should not proceed with the procedure. Also, even though this deformity has many cosmetic and psychological components, the author does not advocate this procedure strictly for cosmetic purposes. This surgical technique has many possible complications including scarring and persistent digital deformity, which can often be cosmetically displeasing and require further surgical intervention. The patient must weigh the benefits and risks of the surgical procedure and make an educated decision understanding all potential complications unique to this deformity prior to surgical intervention.

COMPLICATIONS

Although this surgical procedure is technically not that difficult to employ, there are many possible complications. Potential complications for brachymetatarsia repair with callus distraction include but are not limited to hypertrophic scarring, pin loosening, pin tract infections, flexion deformities or deviation of the digit, temporary malalignment, angulation of the metatarsal or malunion, decreased range of motion and stiffness at the metatarsophalangeal joint with or without subsequent arthritis, dislocation or subluxation of the metatarsophalangeal joint, premature consolidation resulting in under-correction, prolonged consolidation time or non-union, over lengthening of the metatarsal, fracture through the bone callous, infection of the bone and or joint, and neurovascular injury.

Although the list of potential complications for brachymetatarsia repair by callus distraction appears quite lengthy, fortunately, many of them are minor and resolve uneventfully when appropriate treatment is instilled. When complications are encountered, expedient identification of the problem and development of a treatment plan are paramount for overall success. The biggest pitfall for a surgeon can be avoiding the realization of a complication. The surgeon must be honest with the patient when a complication is present. Most complications can be treated effectively and successfully even though additional surgery may be warranted. If they are avoided however, they will only worsen and failure is sure to ensue.

Surgeon Dependent Complications

Complications may be surgeon dependent or iatrogenic, or they may be due to patient noncompliance, or they may just be inherent to the procedure itself. Although this is technically not a very difficult procedure to perform, proper execution is necessary to obtain a successful result and minimize potential complications. First, the surgeon has to be meticulous in the soft tissue dissection. There should be minimal periosteal reflection around the osteotomy site; in fact, the author chooses to leave the periosteum intact and perform the osteotomy through the periosteum. This helps maintain vascularity to the site and aids in osteogenesis during the distraction process.

The osteotomy should be made in the proximal metaphysis of the metatarsal because it is a stable area filled with good cancellous bone. This again increases vascularity of the site and helps ensure new bone formation throughout the distraction process. Also, the osteotomy must be perpendicular to the long axis of the bone. If the osteotomy is not made properly, either because of the placement or the design, many possible complications, including malalignment, can result.

Proper pin placement and alignment are also paramount for a successful outcome. The pins must be placed perpendicular to the metatarsal and should be parallel to one another. The external fixator frame should always be used as a guide for all pin placement. This helps ensure accurate distance between each pin and the osteotomy and also helps maintain alignment. If the pins are not placed properly, the pins will be placed under tension when trying to apply the external fixator increasing the risk of complications, such as malalignment and malunion, which can ultimately lead to metatarsophalangeal joint subluxation.

Finally, the surgeon must closely monitor the patient during the postoperative course and supply a clear and concise postoperative regimen for the patient. The surgeon must give the patient detailed instructions about how much to turn, when to turn, and in which direction to turn the device. The author has found it helpful to distribute diagrams and specific, detailed instructions to the patient including a turning check-off sheet. The patient brings this check-off sheet to every appointment and it is dated and copied and placed in their chart. If the patient is honest in their documentation, this could aid the surgeon in determining if the turning increments are appropriate and are yielding the desired results. If it appears as if the distraction process is too slow, the increments can be increased and if it is too fast, they can be decreased. Close, weekly monitoring during the distraction process allows the surgeon to make

modifications easily and effectively to produce a successful surgical result.

Patient Dependent Complications

Due to the significant involvement of the patient postoperatively, the success of callus distraction for brachymetatarsia repair is highly dependent on patient compliance. It is of the utmost importance that the patient understands the significance of their compliance in order to obtain a successful outcome. Proper patient selection, therefore, is critical for the surgeon when utilizing callus distraction for the repair of brachymetatarsia.

Proper timing of the distraction is critical for a successful result. The patient is responsible for actually performing the distraction process and they must comply with the surgeons instructions at all times. For lesser metatarsals, a 1-week latency period is recommended before distraction is begun when the osteotomy is performed in the proximal metaphysis. Latency allows for an increase in vascularity and potential for bone formation. The author has found that the ideal rate of distraction for lesser metatarsals is $5/8$ mm (0.625 mm) per day. This coincides with other recent surgeons recommending between 0.5 mm a day² to 0.7 mm a day.³ The patient turns $1/8$ of a turn 5 times a day. Smaller, more frequent turning intervals results in efficient osteogenesis and yields the best results. For patient compliance and comprehension however, $1/4$ turns may be easier for the patient to understand and have been effective as well. The surgeon can adjust the distraction rate as deemed necessary according to length obtained and callus formation visualized on radiographs.

The patient must turn the device exactly the amount instructed by the surgeon. If they do not turn the device enough, the distraction will be too slow, and the area can begin to consolidate making further distraction impossible resulting in a continued shortened metatarsal. If they turn the device too much, the distraction will be too fast, and the gap may widen too quickly and a nonunion could result. Also, if the patient continues to turn the device, even after the surgeon has instructed them not to, the metatarsal will be over lengthened. One of the most common reasons for an unhappy or displeased patient postoperatively is that the toe is still shorter than they would like it to be. Many times the phalanx in the toe will be short as well as the metatarsal. When the metatarsal has reached its optimal length, the toe will probably still be short. The patient must understand that the metatarsal cannot be over lengthened and they should not try to make the toe longer because significant complications will most likely result. Over lengthening of the metatarsal

usually leads to subluxation of the metatarsophalangeal joint and deviation of the digit. Unfortunately, when over lengthening of the metatarsal results, surgery is usually necessary to obtain full correction. If the patient does not understand that if their toe is short preoperatively, their toe may still be short even after adequate metatarsal length has been obtained, the procedure is doomed to failure.

Finally, the patient should be kept nonweight bearing during the entire postoperative course until osseous consolidation has been achieved. Excessive weight-bearing forces on the metatarsal during the distraction process or ossification period could result in plastic deformation of the immature bone substance and a sagittal plane deformity. When weight bearing is initiated, the external fixator and pins should be left in place. It is felt that this provides some measure of protection against weight-bearing forces on the newly lengthened areas of bone. A gradual disassembly of the frame should then ensue allowing the osseous tissues to adapt to weight-bearing stress over time.

POTENTIAL COMPLICATIONS

In order to have a more organized approach during preoperative discussions with the patient concerning potential complications, they can be divided into 2 categories, minor and major. Minor complications commonly occur with this technique; fortunately however, these complications are typically treated with conservative measures and they usually resolve without any significant sequelae. If clinical symptoms persist from these minor complications, despite conservative therapies, additional surgery can be performed. This subsequent surgery typically involves more basic types of techniques such as soft tissue balancing, digital realignment, and scar excision. Major complications fortunately are less common; however, when they occur they typically require additional surgery for successful structural correction and relief of clinical symptoms. This additional surgery is usually more involved than those of minor complications and typically involves osseous reconstruction as well as soft tissue balancing. As with any other surgical procedure, a complication may begin as minor and progress to major sequelae if proper treatment is not instilled or the patient is noncompliant. The more commonly encountered complications will be reviewed in greater detail including treatment options.

Minor Complications

Hypertrophic scarring is a common complication that can result with callus distraction since the skin and all surrounding soft tissues are lengthened in addition to the

bone with this procedure. Conservative measures can help reduce the thickened scar but if clinical symptoms persist surgical excision of the scar can be attempted. It is imperative that the surgeon discuss the possible complication of a thickened scar preoperatively with the patient when undergoing the callus distraction technique. If the patient is pursuing the surgery primarily for cosmesis, they must understand complications may result which may not be cosmetically pleasing.

Pin loosening may also be encountered. When it occurs, it is typically the frame or hinge loosening around the pin, which can be easily fixed by tightening the device. Pin loosening within the bone typically does not occur. If the pin is placed appropriately intraoperatively, through two cortices, and there is no creation of stress risers, typically the pin does not loosen in the bone. If it appears that the pin is loosened in the bone then the surgeon should evaluate the patient for infection, possible trauma the patient could have experienced postoperatively, or noncompliance of the patient causing possible fracturing or displacement.

Most pin tract infections that occur with this technique are minor complications and usually resolve with local pin and wound care and oral antibiotics. They may however, progress into major complications with significant sequelae; therefore, close monitoring during the postoperative course is essential. It is imperative that treatment be initiated immediately once a pin tract infection is suspected. A delay in treatment could end in disastrous results.

Temporary malalignment of the osteotomy can also occur. If there is mild displacement or malalignment seen on immediate postoperative radiographs prior to the start of the distraction process, typically this malalignment resolves as the metatarsal is lengthened. This displacement can occur for various reasons. There may be excessive manipulation at the osteotomy secondary to the surgeon trying to ensure that the osteotomy is indeed through and through. There could also be excessive soft tissue reflection during the procedure destabilizing the osteotomy site. The osteotomy may be over compressed once the surgeon replaces the external fixator or instability at the osteotomy site may result during the actual frame application. Sometimes the pins have to be manipulated into the frame to fit appropriately and this can cause some displacement of the osteotomy. Typically, as the bone is distracted the soft tissues direct the bone back into a fully corrected position.

If the malalignment occurs during the distraction process itself however, this is a different entity and usually it does not correct itself but worsens as the distraction

process proceeds. This malalignment can result in subluxation of the metatarsophalangeal joint and digital deviation and is typically the result of inaccurate osteotomy design or poor pin alignment. There may however, be an angulation deformity in the metatarsal itself seen on radiographs preoperatively that becomes exaggerated as the metatarsal is lengthened. If malalignment occurs, the distraction process should still be continued until optimal metatarsal length is obtained. Many times, the metatarsal malalignment that is visualized on radiographs is clinically asymptomatic and a good postoperative result ensues. If the malalignment ultimately results in persistent postoperative pain or deformity, additional surgery can be performed to obtain proper alignment of the metatarsal and respective metatarsophalangeal joint and digit.

Probably the most common complication with this procedure is subluxation of the metatarsophalangeal joint and deviation of the toe. This is usually a definite consequence when the metatarsal is over lengthened but it can also occur even when optimal metatarsal length is obtained (Figure 1). When the metatarsal is lengthened, all of the soft tissues including the extensor and flexor tendons are also lengthened. If the tendons do not adapt adequately, despite the gradual lengthening process, tension is placed on the tendons and the metatarsophalangeal joint can sublux and the toe can deviate and rub on an adjacent toe. Sometimes these deformities are minor and resolve with temporary taping and/or strapping during the distraction

process. If the subluxation and digital deformity persist and are clinically symptomatic however, additional surgery may be needed. Typically this subsequent surgery consists of metatarsophalangeal joint release with extensor tendon lengthening and temporary Kirschner wire (K-wire) fixation to help maintain joint alignment.

Major Complications

Over lengthening is one of the most difficult complications to deal with and is usually due to patient noncompliance (Figure 2). The distraction process should be discontinued when the metatarsal has reached optimal length to produce a normal metatarsal parabola. It is recommended that the amount of lengthening achieved should not exceed 40% of the original length of the metatarsal.⁴ When the metatarsal is lengthened greater than 40% of its preoperative length, complications such as decreased range of motion and joint stiffness of the metatarsophalangeal joint, subluxation of the metatarsophalangeal joint with digital deviation, and neurovascular compromise can result.

It is critical that once the appropriate metatarsal parabola is obtained, the distraction process must stop; even if the toe still appears short. This can be a very difficult concept for the patient to understand. Many times, as was stated previously, the phalanges in the toe are short as well as the metatarsal so once the metatarsal has reached the ideal length, the toe will still probably be short compared with the adjacent digits. Patients will visually see that their toe is still short and may try to lengthen the



Figure 1A. Postoperative radiograph at 4 months displays complete consolidation and good metatarsal length. Despite the ideal metatarsal length however, metatarsophalangeal joint subluxation and digital deviation occurred requiring additional surgery.



Figure 1B. Extensor tendon lengthening with metatarsophalangeal joint release and temporary K-wire fixation was performed to gain full correction.



Figure 2A. At 5 weeks postoperative, optimal metatarsal length was obtained and the patient was instructed to discontinue the distraction process.



Figure 2B. The patient continued to turn the device to try to lengthen her toe further despite instructions from the surgeon. At 8 weeks postoperative, the metatarsal is over-lengthened and there is subluxation of the metatarsophalangeal joint.



Figure 2C. At 6 months postoperative, significant subluxation of the metatarsophalangeal joint is noted and the fourth toe is deviated laterally onto the fifth toe. Additional surgery was performed at this point to shorten the metatarsal and realign the digit and metatarsophalangeal joint.



Figure 2D. A shortening metatarsal osteotomy was performed and the metatarsophalangeal joint and fourth toe were realigned and maintained with temporary K-wire fixation. This radiograph reveals complete healing and patient satisfaction at 10 months postoperatively from the original callus distraction. Although the fourth metatarsal is still somewhat longer than ideally desired, good clinical results and patient satisfaction was achieved.

metatarsal more in an attempt to make their toe longer. It is critical for the surgeon to identify this deformity preoperatively if it exists and have a thorough discussion with the patient concerning its effect on the clinical results. If it is not discussed preoperatively, the patient will not understand why their toe still appears short because they believe the surgery should have corrected their short toe.

Sometimes, if the metatarsal is over lengthened the reverse of the distraction process can be employed and the metatarsal can be shortened back to its appropriate length as previously described. Unfortunately, when the metatarsal is over lengthened, the toe usually dislocates at the metatarsophalangeal joint and additional surgery is required for structural correction and proper realignment. This surgery typically consists of shortening the metatarsal back to its appropriate length, releasing the metatarsophalangeal joint, and maintaining alignment with temporary K-wire fixation. It must be stressed that if the metatarsal is over lengthened, it must be shortened in order to release tension from within the joint and surrounding soft tissues or persistent subluxation and re-occurrence will most likely ensue.

Premature consolidation and nonunion are rare with the authors chosen technique. The rate of distraction is the key to avoiding these potential complications. Smaller, more frequent intervals for distraction are recommended. The turning rate preferred by the author for lesser metatarsals is 1/8 mm 5 times a day. This rate has been shown to favor a more gradual relaxation of the surrounding soft tissues producing a more stable neurovascular environment and more efficient osteogenesis. This rate can be modified and increased if premature consolidation is of a concern. Likewise, the rate can be decreased if the distraction appears to be progressing too quickly. Monitoring the distraction process closely and making modifications as necessary will ensure an efficient remodeling process.

The author has never experienced fracture through the bone callus. The osteotomy is made in the proximal metaphyseal bone, which is a stable area of bone. Authors that have encountered fracture through the bone callus as a complication of this procedure have typically performed the osteotomy through the diaphysis.⁵ Also, the author begins weight bearing prior to the removal of the external fixator. This allows the bone to slowly adapt to the weight-bearing stresses over time and helps avoid fracturing through the newly consolidated bone.

Fortunately, the author has never experienced a vascular injury with the callus distraction technique. Since the lengthening is obtained gradually over several weeks, the vascular structures have time to adapt and abrupt vasospasms of the vasculature are avoided. Although neuritis has been encountered by the author, it has always resolved with conservative measures and the author has not experienced any significant or permanent nerve damage with this procedure.

CONCLUSION

Brachymetatarsia repair with callus distraction is a demanding procedure postoperatively on both the surgeon and the patient but it can be a very rewarding surgery with limited complications if the surgeon is diligent in the surgical execution and the patient is compliant with the postoperative regimen. If the patient is educated preoperatively about the deformity itself, the vigorous postoperative course, and all potential complications, they are more likely to have a successful result even if complications arise. Unfortunately, there are a fair amount of complications associated with this procedure and although many of them are minor, the patient must be adequately informed. Many patients are eager to pursue this surgery to improve cosmesis and they can be discouraged postoperatively if their toe is still shorter than they think it should be or if they have a thickened scar. A well-educated patient should understand the potential complications of the procedure and be able to weigh the risks and benefits of the surgery. If they then choose to pursue the surgery, this knowledge should help them have realistic expectations and will usually result in a happier postoperative patient and a higher surgical success.

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