Minimally Invasive Hallux Valgus Correction: Third Generation Treatment Update

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Abstract

The treatment of hallux valgus has been a challenge for surgeons over the last 100 years. It is fascinating because it provides infinite variations on the one diagnosis. And along with the infinite variations, there have been almost an infinite number of procedures described to solve these problems. This article will focus on the indications, techniques, pearls, and pitfalls of minimally invasive hallux valgus correction.

Keywords: Deformity, Hallux, Hallux valgus, Osteotomy.

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Introduction

The treatment of hallux valgus (HV) has been a challenge for surgeons over the last 100 years. It is fascinating because it provides infinite variations on the one diagnosis. And along with the infinite variations, there have been almost an infinite number of procedures described to solve these problems. Also, HV is often associated with other problems in the forefoot. It can be associated with a neuroma. One can have HV with a 2nd plantar plate tear. The HV can often be associated with multiple claw toes. A patient can also have a simple HV on one side and an incredibly complex one on the other side. So, to treat HV problems correctly, one needs to master all of these issues at the same time.

Originally, surgery was focused on the removal of the bunion itself. But as understanding of the mechanics of the foot developed, the procedures changed. Osteotomies of the metatarsal and phalanx along with surgery to correct the soft tissues have all been used to improve outcomes. The major problems have involved recurrence of deformity, stiffness of the joint along with transfer metatarsalgia, and neurological problems. With the foot, one always has concerns about infection related to surgical incisions.

Minimally invasive surgery for HV has been described since the 1940s. This was originally published as the Kramer osteotomy.[1] In this osteotomy, a minimal incision was made to perform a translational osteotomy of the metatarsal. A K-wire was then inserted into the proximal metatarsal canal. Magnan[2] was the first to describe the use of a high-speed burr for the metatarsal osteotomy. Following this, Vernois and Redfern[3] developed stable internal screw fixation for the osteotomy via minimally invasive techniques.

In 2005, Magnan et al.[4] published a series of 118 cases of percutaneous distal metatarsal osteotomy for mild to moderate HV. This produced good results, but there was a high percentage of patients who developed dorsal or plantar displacement of the osteotomy. There were only three recurrences and approximately 10% of patients develop stiffness.

Giannini et al.[5] published a series of 1000 cases of percutaneous bunion surgery in 2013. In this series, he performed a percutaneous metatarsal osteotomy, which was then internally fixed with a K-wire. In this series, all osteotomies are united. The K-wires were removed after 30 days.

In 2013,[3] Vernois and Redfern analyzed 100 cases of minimally invasive Chevron–Akin (MICA) osteotomy procedures. They showed a mean correction of 9° with a 7° reduction of the inter-metatarsal angle. Brogan et al.[6] also reported a similar series of cases using a combined screw and K-wire fixation for 45 patients. There was low evidence of complications and reoperation.

In 2013, Trnka et al. published an article critically reviewing the evidence for minimally invasive HV surgery. They found that although results were good with multiple techniques, the number of studies above level IV were few. They found only one level II and two level III studies.

Surgical technique for third generation minimally invasive Chevron–Akin procedure as performed by the author.

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Minimal Requirements and Steps of

Mini C-arm

It would be extremely difficult to perform minimally invasive bunion surgery without a low dose of image intensifier. This is important for two reasons. Firstly, it is far easier to image the foot from both the frontal and lateral plane using a small device. It also reduces the time taken to set up for X-rays. It would be difficult to maneuver a standard image intensifier machine into the appropriate positions to obtain an accurate view during surgery. Secondly, the number of scans can be large in complicated cases. While each scan is very brief, when a large image intensifier is used, the total dose of radiation can become very high. The smaller image intensifier has a much lower dose, which creates less risk.

Minimally Invasive Burr

The choice of tools to perform minimally invasive surgery is important. This includes both the handpiece and various attachments. The handpiece can come in either high-speed or low-speed and high-torque variations. The high-speed burr is usually used with saline irrigation. The heat generated by the high-speed burr will create necrosis of the bone without irrigation. The low-speed, high-torque burr can be used without irrigation. It is up to the surgeon to decide which is better in their hands.

Patient Selection

In the early phases of minimally invasive bunion surgery, it is best to choose patients that are low demand. These are older patients with low-activity status. Fortunately, they are also the patients that are at higher risk with open surgery. They also commonly have more severe deformities. In the beginning, this is actually an advantage as the most difficult part of minimally invasive surgery for HV is the insertion of the first screw into the metatarsal head. This is easier in more severe deformities as one can obtain a greater translation, which then creates a better angle for screw insertion. For the patient, a minimal approach provides a reduced risk of infection and wound problems as well as a simpler recovery plan.

Patient Position

The patient should be positioned to supine on the operating table with the feet hanging over the edge of the bed. A bolster is often used to elevate the foot slightly, which will allow easier access when inserting wires and screws. One of the key parts of positioning is to allow easy access for the image intensifier in both the anterior and lateral planes. The surgeon will usually perform the procedure from the medial side of the foot. This can be done either in a seated or standing position.

Image Intensifier Position

The image intensifier will need to be placed in the 90° position from the operating table. This will allow for the correct imaging position. The image intensifier can then be moved to obtain all images required. It is good to have an image intensifier with a laser mark that allows for the correct position to be seen on the patient. If this is available, it is useful to perform the procedure without any operating lights on. The operating lights will reduce the ability to see the laser mark. As the procedure is predominantly performed under X-ray, operating lights are not usually necessary.

Tourniquet

While it is not essential to use a tourniquet for minimally invasive surgery, it is the author's preference that it is used. It reduces the risk of blood splatter, which can occur using the burr. Reducing this is beneficial to the surgical team.

Anesthetic

The procedure is quite suitable to be performed under local anesthetic. A local anesthetic with a calf tourniquet is a reasonable selection. The choice of anesthetic will vary depending on local conditions. In many countries, a general anesthetic and thigh tourniquet are common. In the author's country, this is the most common situation. While the use of a sciatic nerve block is very common in foot surgery, a simple ankle block is sufficient for minimally invasive surgery. Numerous studies have now concluded that the pain from this type of surgery is much less than traditional techniques.

Choice of Burr

Two types of burr are required to perform minimally invasive bunion surgery. Firstly, a Shannon type burr is required to perform the metatarsal and phalangeal osteotomies. The initial burr is a 2 mm × 20 mm. This will be used for the metatarsal osteotomy, akin osteotomy, and entry point for the akin screw. The other burr will be a wedge burr. This can be either a 3 mm or 4 mm device. This will be used to remove the bunion.

Initial Portal

The correct position for the first cut is within the neck of the first metatarsal. This is just where the flare of the metatarsal occurs, as it enlarges to form the bunion. This position is localized on the image intensifier and a small incision is made down to the bone. A periosteal elevator is inserted to release soft tissue. Following this, the 2 mm burr is inserted and aimed toward the head of the third metatarsal. This will allow a successful metatarsal osteotomy without shortening. It is best to drill through the center of the metatarsal and stop before executing the further side. At this point, an X-ray should be taken to confirm that the correct alignment has been achieved. Usually, the exit point will be just proximal to the lateral sesamoid. Care must be taken to avoid damage to the local structures. In cadaver studies, it has been shown that the superficial dorsal medial nerve can be damaged. So adequate soft tissue protection is required.

Metatarsal Osteotomy

Once the burr is in place, then the distal cortex can be penetrated. Initially, when the procedure was first described this cut was made in a chevron shape. However, the current trend is for this cut to remade in a straight manner. Initially, the cut is made from the center of the metatarsal to the dorsal surface. Once this has been completed, the plantar cortex can be cut.

Translation (Fig. 1)

The shifting tool is then inserted into the portal. In the first instance, this is used to pass across both cortices and into the metatarsal space. Once in position, the metatarsal head is shifted laterally to help to loosen some of the soft tissues. Once this has been achieved, the shifting tool is then inserted into the metatarsal proximal shaft. The head is then translated and positioned so that the metatarsal

Fig. 1: Translation of metatarsal head to anatomical location over sesamoids

Fig. 2: Initial screw insertion. Exiting lateral side of proximal cortex critical

Fig. 3: Second screw insertion

Fig. 4: Removal of metatarsal prominence

head sits correctly over the sesamoids. When there is a large amount of pronation of these head of the metatarsal, some rotation of the head may be required to assist with positioning. This can be done at this stage and it will be fixed with the initial wire. Confirmation X-rays at this point will confirm appropriate positioning. The most common error in the early periods of this technique is to fail to translate the head sufficiently. This will lead to a higher recurrence. Translation of 100% of the metatarsal is possible and will heal over time with bone remodeling. So it is safe to perform a large translation if it is internally fixed appropriately.

Fixation

Fixation of the osteotomy is mainly down to the surgeon's preference. Fixation can vary from a simple K-wire to a dorsal screw or intramedullary device, but the most common fixation involves two screws from the medial side. The shape and size of the screws have evolved. Initially, 3 mm screws were used. However, in the latest evolution bevel screws of both three and 4 mm are used with minimal compression. The 4 mm cannulated screw is inserted over a 1.2 or 1.5 wire. The 3 mm screw is inserted over a 1 mm wire.

Initial Wire Positioning

The position of the first wire into the metatarsal head is the most critical and yet the most difficult part of the procedure. In the technique that is described here, the first wire enters the base of the first metatarsal from the medial side. This is close to the metatarsal cuneiform joint. The wire will then pass through the medial cortex and the more distal lateral cortex of the first metatarsal before it enters the metatarsal head. This is critical to maintain stability. If the wire does not pass through the lateral cortex on the first metatarsal, distal fixation can be lost and the recurrence will occur. So it is important to emphasize this fact. Obtaining the correct position of the first wire can be difficult. The entry point is critical to allow the correct angle to achieve the correct position in the metatarsal head.

The other important fact to mention is that the position of the metatarsal head in the dorsal and plantar plane needs to be respected. So once the wire is inserted on, an X-ray should be taken in both the anterior and lateral planes. The most common error initially is to plantarflex the metatarsal head. Sometimes, the shifting tool will promote this. A suggestion is to hold the metatarsal head between the fingers to assess its position during translation. The wire should enter the middle of the metatarsal head in the lateral plane.

Initial Screw Insertion (Fig. 2)

Once the first wire is in place, the length of the screw is selected. A drill is inserted into the depth of the wire. This shifting tool is left in place and the head is held in a controlled position. This will prevent any loss of position. The screw is inserted and the bevel is angled to reduce any impingement on the skin and soft tissues. If the screw is inserted correctly, the osteotomy will be stable and it will be safe to remove the shifting tool.

Second Screw Insertion (Fig. 3)

A puncture wound is made in the metatarsal shaft roughly halfway between the two portals. This is confirmed on the X-ray. Through this portal, a wire will be passed from the metatarsal to the metatarsal head, usually parallel to the first screw. When using a 3mm screw, a 1mm wire is used for this part of the procedure. Due to the angles required, it can be difficult to position the wire accurately. This can be overcome by first creating a pilot hole in the metatarsal. This can be done by using the wire and drill from the first screw. Making a hole in the medial cortex will allow easier entry for the 1mm wire and simpler insertion to the head. This hole can potentially affect the fixation of the 3 mm screw, so one needs to be careful. Newer techniques using 3.8 or 4 mm screws, avoid this issue.

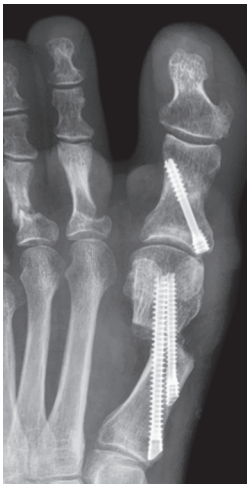

Fig. 5: Final result after Akin osteotomy. Metatarsal remodels to fairly normal shape over 12 months

Metatarsal Edge Removal (Fig. 4)

Once the head is translated and the screws are inserted, the bunion and distal metatarsal edge need to be removed. A periosteal elevator is inserted from the middle portal and soft tissue is released from the edge fragment. Then the Shannon burr is used to remove the edge and smooth the surface. A small piece is often left after this osteotomy, which can be left as a graft or removed depending on its size and position.

Lateral Release

This is a good time to decide if a lateral release is required. Opinions vary, but in general, this is recommended for severe deformities. Percutaneous release of the distal adductor hallucis tendon is sufficient. It is best to locate this area on X-ray before making a portal. The area is between the lateral sesamoid and phalanx in the first interspace. A beaver blade is inserted and its position is confirmed. Sweep the beaver blade 90° to the path of the tendon. A release will be felt and success can be measured by the lateral opening of the joint.

Bunion Removal

Through the initial metatarsal portal, a periosteal elevator is inserted to remove the soft tissue from the bunion. A wedge burr, either 3 or 4 mm is used to remove the prominent bone. Saline irrigation and a rasp are needed to fully remove the debris. Successful removal is confirmed clinically and on X-ray.

Akin Osteotomy (Fig. 5)

If the surgeon can finish the operation with a straight toe, the risk of recurrence is much lower so the akin osteotomy is a very useful tool. The most experienced bunion surgeons will use the akin osteotomy for the majority of cases. This is even more important because with the minimally invasive surgery technique medial capsular plication is not used.

The initial part of the akin involves creating a pilot hole for the 3 mm screw. This is a standard cannulated headless screw. A portal is made on the medial side and the Shannon burr is inserted. A hole is made on the medial proximal end of the phalanx and aimed obliquely to the lateral side. Do not exit the lateral cortex. This is just to make the later insertion of the 1mm wire easier.

In the distal, one-third of the phalanx makes a medial portal. Insert the Shannon burr and make an oblique entry aiming for the proximal medial part of the phalanx. Remove the dorsal and plantar cortex on this line but leave the lateral cortex intact. This can be quite delicate, so slow progress is best. Once you feel that the desired correction is obtained, insert the 1mm wire from the first portal. You will find that this will cross the osteotomy at a 90° angle. Drill the lateral cortex and insert the screw, which will provide good compression.

X-rays

At this point, the bunion should have been removed, the metatarsal head will be above the sesamoids, the articular surfaces aligned and the toe straightened. For the uninitiated, the metatarsal will look quite unusual, but over 12 months almost complete remodeling will happen. It is important to remind patients of this.

Bunion

The skin over the bunion can look bulbous after removal. Nothing needs to be done here, as this will shrink away over 6–10 weeks. In my early experience, I would place a percutaneous suture in the skin to pinch it together and remove it at 2 weeks. I no longer see the need to do this.

What if the Foot is Still not Corrected?

If you experience this, it is because one of the steps is incorrect. Almost always, it is because the initial metatarsal head translation is not sufficient. It is almost impossible to over-translate and even 100% translations heal well. So look at this first. Next check that the lateral release is adequate. Is akin correction enough? If you are happy with all of these things, you will not be disappointed. There are instances where surgeons have opened the medial capsule and tightened this. If you feel this is essential, then go ahead but I have personally never had to do this.

Closure and Dressing

This is quite simple. Some prefer small sutures and some just Steri-Strips. Healing is rapid, and wound problems and infection are extremely low incidence. For dressings, ensure that the toe is placed in the final position. The French style forefoot dressing technique is very effective. One uses elongated saline-soaked gauze. This is placed between each toe and over the surgical site. A crepe bandage over this is all that is needed. Blood that leaks from the wound will be drawn away from the skin. The moisture from the bandage dries in 24 hours and while the dressings can look reddened, the underlying foot is clean.

Postoperative Care

Weight-bearing is permitted but to reduce swelling ask patients to keep things to a minimum for the first two weeks. A postoperative shoe is used. The usual orthopedic review time of two weeks is common, but for minimally invasive surgery cases one week is sufficient. After this, patients can shower and move-about more freely.

Splintage

Once the patient leaves surgery, the care is only just beginning for this procedure, not finishing. For many cases, the toe sits perfectly and will recover without any further care. But the soft tissues are affected by muscle activity and scar tissue, and this will affect the

toe position as well as range of motion. These issues have caused drawbacks in both minimal and traditional techniques.

In the minimally invasive surgery technique, holding the toe straight to allow the medial capsule to shrink and gain strength is important. The European method involves continued strapping and taping. This will assist with swelling control as well. There is no need for the plaster. The bunion sleeve, invented in Japan, is a useful device to perform a similar task. This is the author's preferred method. It is worn during the day for 6 weeks and removed for showering and sleeping. If the sleeve is too tight, there is a risk of varus, so correct sizing is required.

Movement

Range of motion (ROM) exercises is required. Although it is easier than traditional methods. Dorsiflexion is rarely an issue, but plantar flexion seems to be slower to recover. So ROM exercises are used but focus more on plantar flexion. It is thought that the scar tissue from the bunion removal can affect plantar flexion early on. These exercises should be started early but remind patients that their final ROM may not be obtained for up to 3 months.

Review

In the early days, see patients every 2 or 3 weeks. It will allow for fine-tuning and the patient will be pleased for the care. As experience is gained, stretch this out. By 8 weeks it will be clear that the patient will have a successful result, although there is still swelling at this point. In standard orthopedic practice, 6-week X-rays are usually obtained. This invariably looks as though no healing has occurred, but as long as the foot is healthy and the position is maintained, do not be concerned. An X-ray around 4 to 6 months is best.

Results

Locatelli et al.[7] recently published successful results for minimally invasive surgery bunion correction using no fixation. This would be useful for cost-benefit, but patients were required to use significant bandaging for 6 weeks. With the described technique in this paper, patients are free to go without bandaging after one week.

Holme et al.[8] published results this year using a similar technique to the author for 40 patients. 70% of the results were excellent at 12 months and 30% were good. Phalangeal hardware removal was the only occasional complication.

Kaufmann et al. in 2017[9] showed significantly improved patient satisfaction with minimally invasive bunion correction compared to open techniques. Also in 2017, Lee et al.[10] published a prospective, randomized trial in 50 patients showing less pain in the minimally invasive group.

Hernandez et al.,[11] with 45 patients and a 5 year follow-up showed a 97% satisfaction rate. There were four cases of screw removal. Significant improvements in the HVA and IMA were seen.

Complications

Jowett and Bedi[12] published a study involving 106 patients prospectively. They had a complication rate of 14% due to hardware issues, nonunion, and recurrence. As with all bunion procedures, most issues revolve around recurrence, stiffness, and hardware, as well as nerve trouble. Following this program should provide the best defense against the first two. Using beveled screws will significantly reduce the need for hardware removal. But given the closeness to the skin of the metatarsal occasionally this will occur. Percutaneous screw removal leads to simple and swift recovery. Nerve pains occur intermittently in percutaneous surgery and are not always anatomically related. Methods to stimulate the microcirculation are helpful.

Heterotopic ossification is a random occurrence around the bunion area. Inadequate clearance is the most likely cause. It can be simply removed with a burr, but it is important to emphasize full irrigation and removal of excess bone.

These principles apply to mild, moderate, and severe HV which can all be treated successfully with minimally invasive surgery techniques. Further studies will provide greater evidence regarding long-term success. As the knowledge and innovation of minimally invasive surgery develop, so will the widespread uptake.

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