



Percutaneous, MIS and open hallux valgus surgery

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- There is some confusion in the terminology used when referring to MIS (Minimal invasive surgery) or percutaneous surgery. The correct term to describe these procedures should be percutaneous (made through the skin) and MIS should be reserved for procedures whose extent is between percutaneous and open surgery (e.g. osteosynthesis). Minimal incision surgery may be distinguished in first, second and third generation minimal incision surgery techniques.
- First generation MIS hallux valgus surgery is mainly connected with the Isham procedure; an intraarticular oblique and incomplete osteotomy of the head of the first metatarsal without fixation.
- The Bösch osteotomy and the SERI are classified as second generation MIS hallux surgery. They are both transverse subcapital osteotomies fixed with a percutaneous medial K-wire inserted into the medullary canal. For all these procedures, intraoperative fluoroscopic control is necessary.
- Open hallux valgus surgery can be divided into proximal, diaphyseal and distal osteotomies of the first metatarsal. Reviewing the available literature suggests minimally invasive and percutaneous hallux valgus correction leads to similar clinical and radiological results to those for open chevron or SCARF osteotomies. First generation minimally invasive techniques are primarily recommended for minor deformities. In second generation minimally invasive hallux valgus surgery, up to 61% malunion of the metatarsal head is reported. Once surgeons are past the learning curve, third generation minimally invasive chevron osteotomies can present similar clinical and radiological outcomes to open surgeries. Specific cadaveric training is mandatory for any surgeon considering performing minimally invasive surgical techniques.

Keywords: MIS; open hallux valgus surgery; percutaneous surgery

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Hallux valgus is one of the most common pathologies of the lower extremity. Nix et al¹ performed a systematic review and meta-analysis on the prevalence of hallux valgus. In 78 reviewed papers the pooled prevalence

estimated for hallux valgus was 23% in adults aged 18–65 years (male: 8.5%, female: 26.3%) and 35.7% in adults aged over 65 years (male: 16%, female: 36%). The earliest reports of surgical hallux valgus correction with resection of the metatarsal head date back to the 19th century.² Reverdin, in 1881,³ was the first to describe an open subcapital closing wedge for the correction of hallux valgus deformity. It later became more popular as the Hohmann procedure⁴ and many years later when used in a minimal surgery fashion as the Isham osteotomy.⁵

From the beginning of the use of osteotomies for the treatment of hallux valgus deformities, surgeons distinguished between distal, diaphyseal and proximal osteotomies. While the Hohmann,⁴ the Wilson,⁶ the Mitchell⁷ and the Chevron/Austin⁸ osteotomies were representatives of the distal type of osteotomy, the Ludloff,⁹ crescentic Mann osteotomy¹⁰ and proximal Chevron¹¹ were representatives of the proximal osteotomies. The SCARF is a diaphyseal osteotomy. In 1974, Helal counted over 150 different techniques which appeared in the literature.¹²

Roger Mann¹³ and Wanivenhaus¹⁴ both established algorithms according to the severity of the deformity for the correction of hallux valgus deformity. In 1945, Polokoff reported a system of subdermal surgery as the first attempt for minimal incision hallux valgus surgery.¹⁵ By the 1960s, power-operated burrs and shavers became available.¹⁶ With these small power instruments older techniques like the Reverdin or Hohmann procedures were manageable via tiny incisions and were renamed Isham, Bösch osteotomy,^{5,17} or SERI.¹⁸ (Simple, Effective, Rapid, Inexpensive)

There is some confusion in the terminology used to refer to MIS (Minimal invasive surgery) or percutaneous surgery. The correct term to describe these procedures should be percutaneous (made through the skin) and MIS should be reserved for procedures situated in extent between percutaneous and open surgery (e.g. osteosynthesis).¹⁹ Minimal incision surgery may be distinguished as first, second and third generation minimal incision surgery techniques.

First generation MIS hallux valgus surgery is mainly connected with the Isham procedure (Fig. 1); an intraarticular oblique and incomplete osteotomy of the head of the first metatarsal. The principle of this technique dates

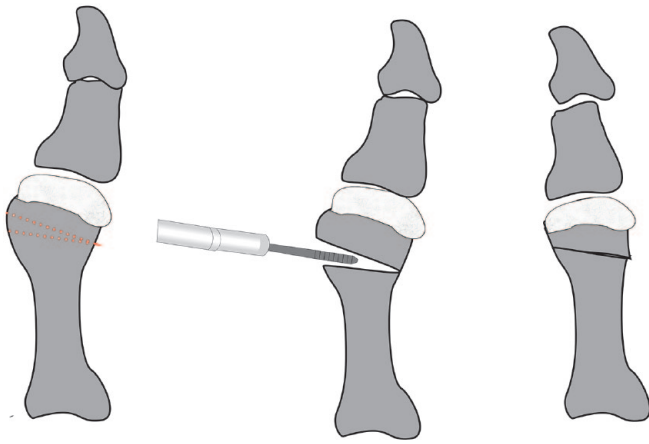


Fig. 1 The Isham–Reverdin osteotomy.

back to the Reverdin osteotomy from the 19th century.¹⁹ A correction of the IM (Intermetatarsal) angle will not be achieved. This technique is performed with fluoroscopic control without fixation.

The Bösch osteotomy (Fig. 2)^{17,20} and the SERI¹⁸ are the examples of second generation MIS hallux surgery. They are both transverse subcapital osteotomies fixed with a percutaneous medial K-wire inserted into the medullary canal and represent a modification of the Hohmann osteotomy first described in 1923.⁴ While the Bösch osteotomy is a percutaneous osteotomy with a 2 mm burr, the SERI osteotomy is performed through a small incision with

an oscillating saw. No additional soft tissue release is performed. For both procedures, intraoperative fluoroscopic control is necessary.

The third generation MIS hallux valgus correction osteotomies have evolved from the Chevron type osteotomies (Fig. 3).^{8,19} The osteotomy is performed percutaneously with a 2 mm burr under fluoroscopic control. The translation of the metatarsal head is achieved by placing a periosteal elevator through the portal into the diaphysis of the proximal fragment and levering the distal fragment laterally. One or two Herbert-type screws are used to gain extra stability, which allows faster rehabilitation.

Open hallux valgus surgery can be divided into osteotomies performed on the proximal, diaphyseal and distal regions of the first metatarsal. Since most of the MIS and percutaneous hallux valgus correction is described on the distal metatarsal, for this article I have also discussed distal and diaphyseal osteotomies for comparison.

According to the hallux valgus treatment algorithm of the Austrian Foot and Ankle Society,¹⁴ the most common internationally used osteotomies in this area of the metatarsal are the Kramer, the Chevron/Austin (Fig. 4), and the SCARF osteotomy (Fig. 5).

Reverdin³ and Barker²¹ were the first to describe distal medial closing wedge metatarsal osteotomies for hallux valgus correction. In 1921, this procedure was popularized by Hohmann.⁴ The downside of the original technique was the necessity of a cast and the resulting shortening of the metatarsal. To compensate for these undesired

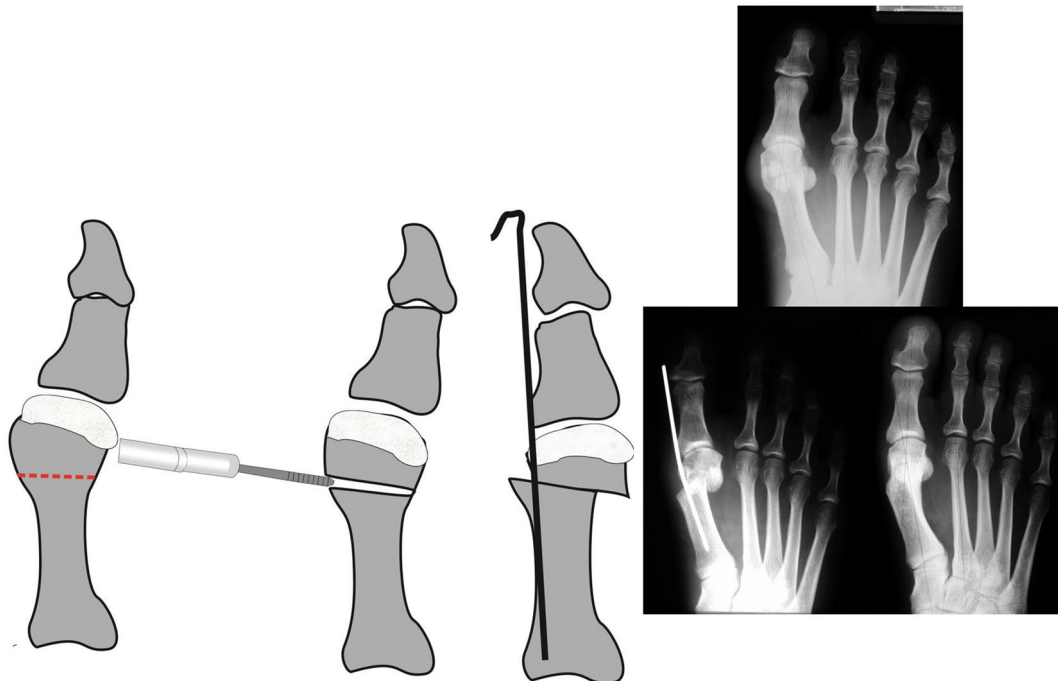


Fig. 2 Bösch osteotomy. Case: 25-year-old female preoperatively, four weeks and one year after surgery.

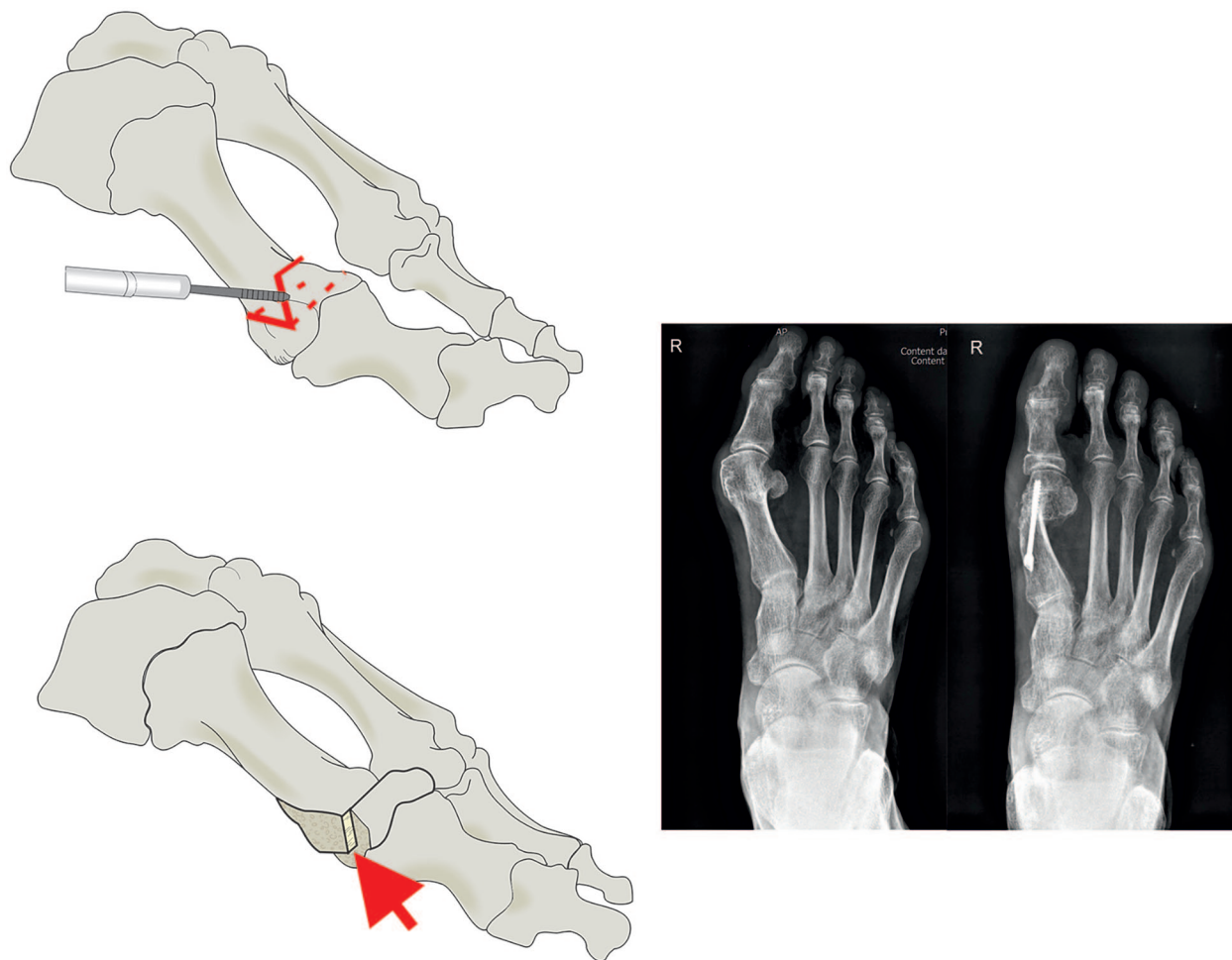


Fig. 3 MIS (Minimal invasive surgery) Chevron osteotomy: 65-year-old female preoperatively and six weeks after surgery.

Source: Case courtesy of G. Kaufmann.

effects, Kramer²² modified the original technique with a lateral translation osteotomy and added a Kirschner-wire fixation. This procedure is still in use.^{23,24} In the Kramer osteotomy, a dorsomedial skin incision is used, and the periosteum is elevated circumferentially from the metatarsal neck and, using a power saw, transverse subcapital osteotomy is performed and the distal fragment is shifted laterally. The hallux is held in a minimal overcorrection position and a percutaneous Kirschner-wire from the tip of the first toe, medial to the displaced head into the shaft of the first metatarsal which is retained for six weeks.

In 1962, Austin performed his first horizontally directed 'V' osteotomy.⁸ In the initial report by Austin and Leventen no fixation was mentioned. They suggested that the shape of the osteotomy and impaction of the cancellous capital fragment upon the shaft of the first metatarsal provided sufficient stability to forego fixation. Over the decades research on K-wire fixation and screw fixation with various types of screws has been published.^{25,26}

A skin incision is made at the medial aspect of the first MTP (Metatarsophalangeal) joint. The metatarsal head is then exposed, and Hohmann retractors are placed dorsal and plantar just extraarticular of the first metatarsophalangeal joint. The medial eminence is now minimally shaved to achieve an even surface. A 1.0 mm Kirschner-wire is placed minimally dorsal to the centre of the exposed medial eminence. This wire is generally inclined 20° from medial to lateral, aiming at the head of the fourth metatarsal. Using a saw guide, two cuts at an angle between 60° and 80° are then made with an oscillating power saw. The distal fragment is translated laterally and fixed with a screw. In general, a lateral soft tissue release is added either transarticularly or via a second incision over the first webspace.

The SCARF osteotomy was first described by Burutaran²⁷ in 1976, followed by American podiatrists.^{28,29} Borrelli and Weil³⁰ and Barouk³¹ then popularized this technique worldwide. Using a straight midline incision,

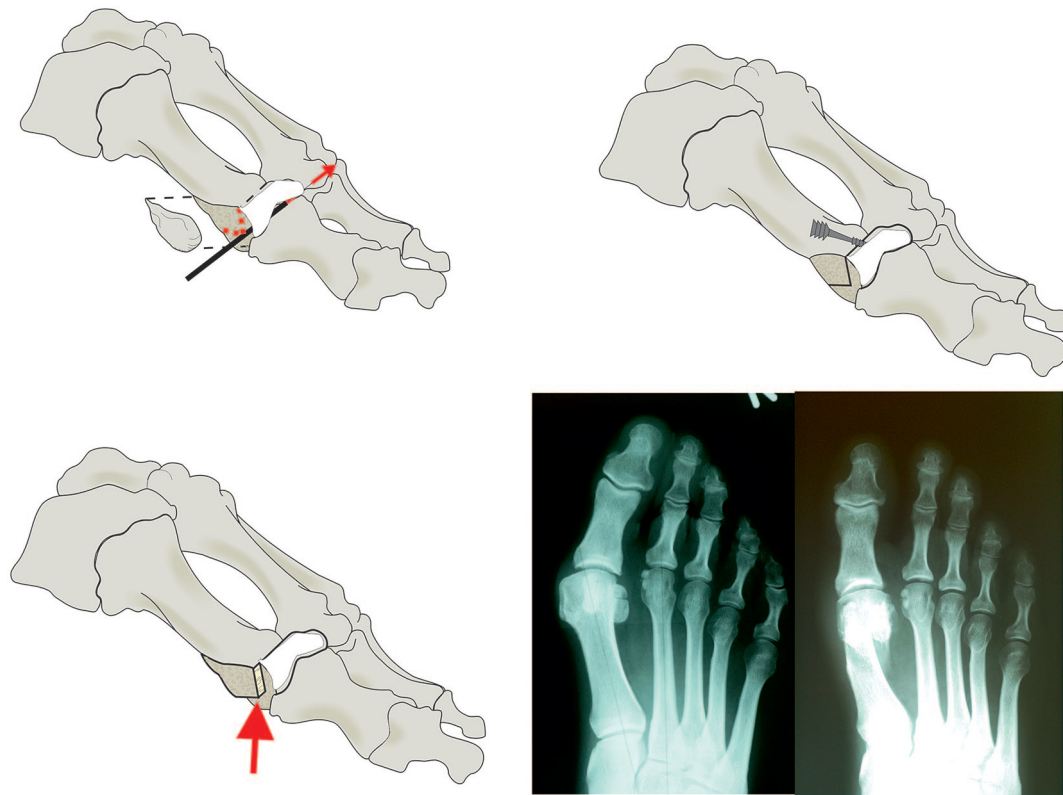


Fig. 4 Austin/Chevron osteotomy. Case: 53-year-old female preoperatively and two years after surgery.

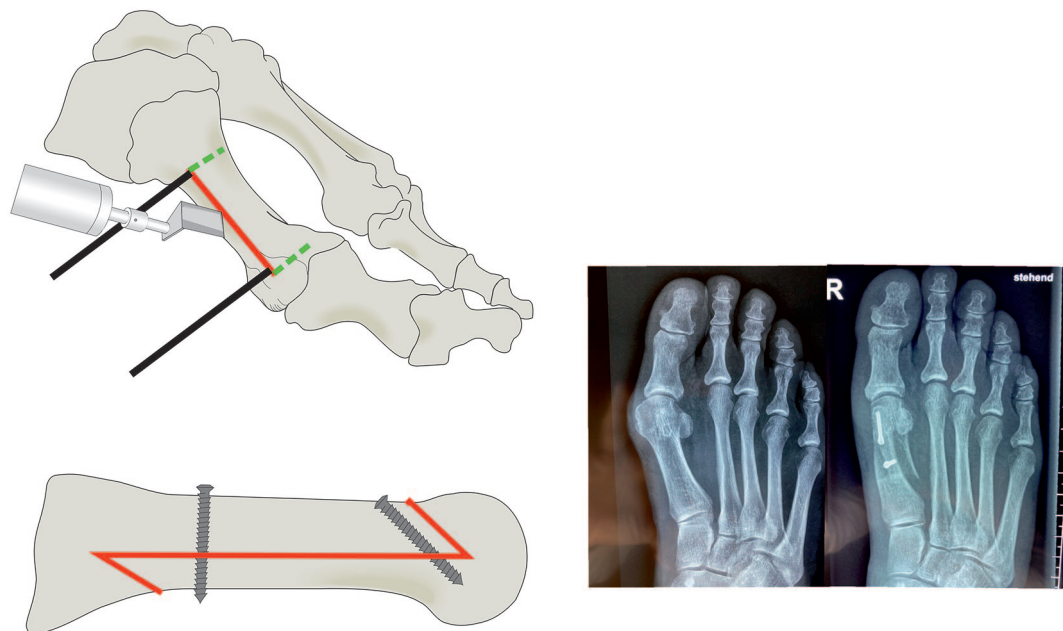


Fig. 5 SCARF osteotomy. Case: 57-year-old female preoperatively and four weeks after surgery.

the metatarsal is exposed. A lateral soft tissue release is performed. After placing two K-wires to mark the two edges of the Z-type osteotomy, the osteotomy is performed by

using a power oscillating saw. After lateral translation of the plantar fragment fixation is achieved by using two Herbert-type screws.

Results

First generation MIS

Bauer et al³² presented a multicentre study of the distal percutaneous metatarsal osteotomy according to Isham with a mean follow-up of 13 months (12–24 months). The AOFAS score (American Orthopaedic Foot and Ankle Society) improved from 52 points on average preoperatively, to 93 points at follow-up. The median range of motion reduced from 90° preoperatively to 75°, which is an average of 17% loss of motion. Neither nonunion, AVN 8avascular necrosis) or malunion of the capital fragment were reported.

Biz et al³³ performed, between 2010 and 2012, a consecutive series of the combined Akin and Reverdin–Isham osteotomies on 80 patients. Complete healing was achieved by three months. Complications occurred in 25 patients (31.25%) including access portal burns during surgery, loss of range of motion in 16 patients and recurrence of deformity in five cases.

Second generation MIS

Bösch et al¹⁷ presented their preliminary results with the SCOT (Subcapital Metatarsal First Osteotomy) technique. The average follow-up was 16 months (range 8–32 months). Range of motion of the MTP-1 joint decreased in 31.5% of the patients. The incidence of pin tract infection of the temporary K-wire was 9%. In a follow-up study in 2000¹⁷ the incidence of infection was reduced. Evaluation of the hallux valgus and intermetatarsal angle at follow-up revealed pathologic values on average (19° HV hallux valgus) angle and 10° IM angle). Portaluri³⁴ published, in 2000, a series of the Bösch technique in 143 patients with 182 operated feet with similar results.

Magnan et al,²⁰ in 2005, reported on 118 consecutive percutaneous distal metatarsal osteotomies at an average of 35.9 months follow-up. Significant correction of all radiological parameters was reported. Quite interesting was the incidence of malalignment of the metatarsal head. In 61%, either plantar or dorsal displacement of the capital fragment was noted.

In a series by Iannò et al³⁵ significant correction of hallux valgus and intermetatarsal angle was noted. But an overall complication rate of 29.4% with recurrence of deformity in 18.8% lead the authors to the conclusion that caution should be exercised when using this technique. Enan and colleagues³⁶ reported 55.6% of either dorsal or plantar displacement of the distal fragment.

Giannini et al¹⁸ presented a series of 641 patients with 1000 osteotomies. Contrary to the above-mentioned results, he reported no nonunion and only eight cases of dorsal malalignment out of 1000 osteotomies.

Poggio et al³⁷ reviewed a series of MIS Kramer (Bösch) and SCARF osteotomies to evaluate the costs. Patients in the Kramer group made significantly more visits (especially

emergency room visits, due to the higher number of complications) and the economic cost of follow-up was greater. They concluded that the MIS Kramer osteotomy had a significantly higher care burden and was therefore less cost-effective. The analysis of these data has resulted in the abandonment of the Kramer osteotomy technique.

Third generation MIS

Vernois and Redfern³⁸ reported the results of 100 feet treated with a percutaneous Chevron osteotomy. Radiological analysis revealed a correction of the intermetatarsal angle from 14.5° to 5.5° at the last follow-up. The mean hallux valgus angle was corrected from 33.7° preoperatively to 7.3° at the last follow-up. Patient-reported satisfaction rate was 95% good/excellent results.

Jowett and Bedi³⁹ reviewed the learning curve of the first 120 minimally invasive Chevron osteotomies by dividing the population into group A (first 60) and group B (consecutive 60). Patient satisfaction and radiological correction were better in group B, but results were statistically not significant. There was a learning curve, but results were promising and comparable to open hallux valgus surgery.

Kaufmann et al⁴⁰ published, in 2020, a series of 19 minimally invasive Chevron osteotomies assessed at six and 12 weeks, 9 months, and five years postoperatively. The K-wire used for fixation had to be removed in 16 of the 19 cases.

Lucas y Hernandez et al⁴¹ presented a series of 38 patients who underwent 45 extraarticular reverse-L Chevron (PERC) osteotomies. With a mean follow-up of 59.1 months (45.9 to 75.2), the AOFAS score increased from 62.5 (range, 30 to 80) preoperatively to 97.1 (range, 75 to 100). There was a statistically significant decrease in the hallux valgus angle and the intermetatarsal angle. With a mean preoperative hallux valgus and intermetatarsal angle of 26 degrees and 11 degrees, respectively, these patients presented mainly mild deformities.

A series of 25 minimally invasive Chevron/Akin osteotomies was reviewed by Lee et al.⁴² Six patients required removal of the screws because of prominence of the screws under the skin. Significant improvements in the hallux valgus angle and the intermetatarsal angle were observed at final follow-up ($P < .05$).

Comparative studies open hallux surgery vs. minimal incision hallux valgus surgery

Lee et al⁴² compared percutaneous Chevron/Akin (PECA) and open SCARF/Akin osteotomies. Both groups showed significantly improved clinical and radiological results. The PECA group showed significantly lower pain level (visual analogue scale) in the early postoperative phase. No serious complications were observed in either group.

Kaufmann et al⁴⁰ published, in 2020, a randomized controlled study of minimally invasive distal metatarsal

chevron osteotomy and open chevron with five-year follow-up. No significant differences were seen between the two groups within five years postoperatively in terms of clinical outcomes (VAS, AOFAS, satisfaction), radiographic outcomes, joint degeneration, or range of motion.

A retrospective cohort study of 49 minimally invasive versus and 32 open distal Chevron osteotomies was reviewed by Brogan et al.⁴³ Clinical and radiologic postoperative scores in all domains were substantially improved in both groups but there was no statistically significant difference in improvement of any domain between open and MIS groups. There were no significant differences in complications between the two groups.

A comparative study of 31 feet treated with the Bösch osteotomy and 33 feet treated with a Chevron osteotomy was presented by Radwan and Mansour.⁴⁴ The mean operative time was shorter in the Bösch group (50.86 minutes versus 58 minutes). Both osteotomies yielded similar clinical and radiological results.

Mafuli et al⁴⁵ compared a group of 36 SCARF osteotomies with a group of 36 Bösch osteotomies. They also noted significantly shorter surgical time with the Bösch osteotomy and comparable clinical and radiological results.

In a cost-comparison study by Poggio et al,³⁷ the minimally invasive Kramer osteotomy presented significantly higher care burdens, complication rates and associated costs during the first year of follow-up.

Conclusion

When reviewing the available literature, minimally invasive and percutaneous hallux valgus correction lead to similar clinical and radiological results as the open chevron or SCARF osteotomies. First generation minimally invasive techniques are primarily recommended for minor deformities since they are performed without translation of the capital fragment and therefore avoid the potential of reduction of the intermetatarsal angle. They similarly avoid the potential risk of joint incongruity. In second generation minimally invasive hallux valgus surgery, Magnan et al²⁰ and Enan et al³⁶ reported 61% and 55.6% malunion of the metatarsal head. Poggio et al³⁷ investigated the cost-effectiveness of the MIS Kramer (Bösch) osteotomy compared to the SCARF osteotomy and demonstrated significantly higher cost burden of the MIS Kramer (Bösch) osteotomy and therefore abandoned the technique. Third generation minimally invasive Chevron osteotomies present similar clinical and radiological outcomes. Once the surgeons were past the learning curve the complication rate was similar to open chevron or SCARF. The benefit is the size of the incision; the disadvantage being the length of radiation exposure. Redfern and Perera⁴⁶ pointed out that specific cadaveric training is mandatory for any surgeon considering

performing minimally invasive surgical techniques, and this training is vital to avoid unnecessary complications and to minimize the surgeon's learning curve.

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