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Clinical and Radiological Outcomes Comparing Percutaneous Chevron-Akin Osteotomies vs Open Scarf-Akin Osteotomies for Hallux Valgus

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Abstract

Background: Minimally invasive surgeries have gained popularity due to less soft tissue trauma and better wound healing. To date, limited studies have compared the outcomes of percutaneous and open osteotomies. This study aims to investigate the clinical and radiological outcomes of percutaneous chevron-Akin osteotomies vs open scarf–Akin osteotomies at 24-month follow-up.

Method: We reviewed a prospectively collected database in a tertiary hospital hallux valgus registry. Twenty-nine feet that underwent a percutaneous technique were matched to 58 feet that underwent open scarf and Akin osteotomies. Clinical outcome measures assessed included visual analog scale (VAS) scores, American Orthopaedic Foot & Ankle Society Hallux Metatarsophalangeal-Interphalangeal score (AOFAS Hallux MTP-IP), and Short Form 36 (SF-36) Health Survey. Radiological outcomes included hallux valgus angle (HVA) and intermetatarsal angle (IMA). All patients were prospectively followed up at 6 and 24 months.

Results: Both groups showed comparable clinical and radiological outcomes at the 24-month follow-up. However, the percutaneous group demonstrated less pain in the perioperative period ($P < .001$). There were significant differences in the change in HVA between the groups but comparable radiological outcomes in IMA at the 24-month follow-up. The percutaneous group demonstrated shorter length of operation ($P < .001$). There were no complications in the percutaneous group but 3 wound complications in the open group.

Conclusions: We conclude that clinical and radiological outcomes of third-generation percutaneous chevron-Akin osteotomies were comparable with open scarf and Akin osteotomies at 24 months but with significantly less perioperative pain, shorter length of operation, and less risk of wound complications.

Level of Evidence: Level III, retrospective comparative series.

Keywords: hallux valgus, wound complication, minimally invasive, percutaneous, chevron, Akin

Without an established gold standard, there are 130 open procedures described for the treatment of hallux valgus.[11] However, 15% of the postoperative patients have complications such as pain, slow recovery, stiffness, and other surgery-related complications.[21,30] In view of this, minimally invasive surgery (MIS) and percutaneous operations have emerged as a more appealing option and gained popularity in recent years among orthopaedic surgeons, due to benefits such as less postoperative pain, faster recovery, decreased rehabilitation time, smaller scars, and thus lesser risk of infections and wound complications.[22,25] However, some studies also reported good clinical outcomes but high complication rates such as high risk of dorsal malunion.[17] Recent review articles also concluded that currently there is still a lack of strong evidence to recommend minimally invasive surgery over traditional open surgery.[24,29,31] This could be due to the majority of the early studies being case series without a control or comparison group.

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To date, limited studies have evaluated the outcomes of minimally invasive techniques and traditional open corrective surgeries for hallux valgus. Brogan et al[6] conducted a retrospective study that showed that the MIS technique was able to achieve comparable clinical outcomes to traditional open techniques at a 2-year follow-up. A prospective randomized controlled trial by Lee et al[20] showed both groups demonstrated comparable good to excellent clinical and radiologic outcomes at a 6-month follow-up, with the percutaneous chevron-Akin (PECA) group having significantly less pain in the first 6 weeks following surgery.

This present study aims to investigate the clinical and radiological outcomes of the PECA technique vs open scarf and Akin osteotomies at a 24-month follow-up. We postulated that the PECA technique would have comparable clinical and radiological outcomes compared with open scarf and Akin osteotomies, as well as less wound complications at a 24-month follow-up.

Methods

We reviewed a prospectively collected database in a tertiary hospital hallux valgus registry. We identified 29 feet that underwent a percutaneous technique from 2013 to 2014 as the study group. These surgeries were performed by the second to last author (Y.C.S.N.) as well as the senior author (K.K.). The study group was then matched to a control group of 58 feet in a 2:1 ratio that underwent open scarf and Akin osteotomies. The patients were matched by sex, age, side of operation, and body mass index (BMI). The indications for surgery were painful hallux valgus and failed conservative management. The exclusion criteria were rheumatoid arthritis, peripheral vascular disease, neuromuscular disease, and patients with recurrent hallux valgus. There was no significant difference in age, BMI, sex, or side of operation between the 2 groups at 6 and 24 months as they were matched paired (Table 1).

All patients were assessed by an independent allied health staff preoperatively at 6 and 24 months postoperatively. The demographics of the patients, including age, sex, and BMI, were collected preoperatively. Clinical outcomes were measured through American Orthopaedic Foot & Ankle Society Hallux Metatarsophalangeal-Interphalangeal (AOFAS Hallux MTP-IP),[19] visual analog scale (VAS) scores,[26] and the Short Form 36 Health Survey (SF-36) score[16] preoperatively and postoperatively. Also, the perioperative VAS score was collected during the patient hospitalization period.

Pre- and postoperative weightbearing anteroposterior and lateral radiographs of the affected foot were taken for all patients to evaluate and classify the severity of the deformity and to determine the amount of correction required during surgery. The senior authors performed the radiographic analysis preoperatively and postoperatively. The radiological parameters assessed were the hallux valgus angle (HVA) and intermetatarsal angle (IMA). The HVA was measured through the anteroposterior view as the angle between the long axis of the first metatarsal and the long axis of the proximal phalanx. The intermetatarsal angle was measured between the long axis of the first metatarsal and long axis of the second metatarsal. The HVA was categorized as mild (15-20 degrees), moderate (21-39 degrees), and severe (≥40 degrees). The IMA was categorized as mild (10-14 degrees), moderate (15-19 degrees), and severe (≥20 degrees).[28]

Table 1. Patient Demographics.

Demographics	Minimally Invasive Surgery	Open	*P* Value
Sex, male/female, No.	4/25	6/52	.725
Age, mean ± SD, y	54.3 ± 12.8	54.3 ± 12.7	.986
Body mass index, mean ± SD, kg/m^2	23.9 ± 3.1	23.7 ± 2.1	.713

Figure 1. Intraoperative radiographs showing chevron osteotomy performed using a Shannon burr.

PECA Technique

The operative technique described in this study is a modification from the minimally invasive chevron-Akin (MICA) procedure as introduced by Vernois and Redfern.[32] The patient was in a supine position and a tourniquet was not inflated.

Two lines were drawn to mark out the dorsal and plantar aspect of the first metatarsal. A beaver blade was used to make a 3-mm incision over the dorsomedial border of the first metatarsal at the base of the flare of the medial eminence. This was followed by the introduction of a specific straight periosteal elevator distally to create a puncture just proximal to the capsular attachment on the medial eminence.

The chevron osteotomy was performed using a 2 × 20-mm Shannon burr (Wright Medical UK Ltd, Hertfordshire, UK) positioned at the metatarsal (MT) neck (Figure 1). Under the image intensifier guidance, this was angled distally toward the fifth MT head and plantarward by 15-20 degrees. The V-shaped

Figure 2. Intraoperative radiographs showing displacement of the osteotomy.

Figure 3. Intraoperative (A) anteroposterior and (B) lateral radiographs showing internal fixation with a cannulated compression screw.

chevron osteotomy was completed after both dorsal and plantar limbs were created. A periosteal elevator was inserted into the intramedullary canal of the first MT to serve as a lever to displace the MT head (Figure 2). The position was then checked with the image intensifier and adjusted accordingly. A guidewire was inserted obliquely through a separate incision made approximately 3 cm proximal to the first incision. The wire advanced across the osteotomy site into the MT head, remaining outside the first metatarsophalangeal joint space, and the cannulated compression screw was inserted (Figure 3). A distal soft tissue release was performed through a 3-mm incision over the lateral metatarsophalangeal joint, just lateral to the extensor hallucis longus tendon. Then, an Akin osteotomy was also performed (Figure 4).[7] Any bony prominence medially was removed via a mini-open 5-mm incision with a rongeur.

Open Technique

The operative technique was the same as described by Barouk.[1] At our center, 2 cannulated, self-tapping, headless compression screws were used to fix the scarf osteotomy cut. For the Akin osteotomy, the proximal phalanx medial closing wedge osteotomy was fixed with a staple (Figure 4).

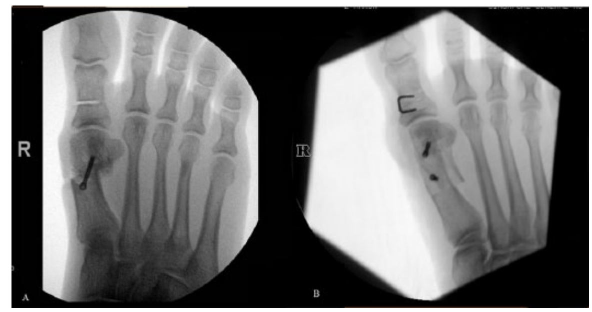

Figure 4. Intraoperative radiographs comparing (A) percutaneous chevron-Akin osteotomies and (B) open scarf–Akin osteotomies.

Postoperative Management

Postoperatively, a special strapping technique was used to maintain the operative correction for 6 weeks.[3] Patients were given a rigid flat shoe (Darco boots; DARCO (Europe) GmbH, Raisting, Germany) and allowed to weightbear fully for the first 6 weeks. At 6 weeks, if radiographs showed signs of bony union, patients were allowed full weightbearing in normal shoes. They were reviewed in clinic at 1 week, 2 weeks, 6 weeks, 3 months, 6 months, 1 year, and then 2 years postoperatively.

Statistical Analysis

Power analysis was performed to ensure that the study sample size was adequate. A sample size of 29 cases and 58 controls was estimated based on a 1:2 matching and an odds ratio of 0.2. The sample size was based on achieving a 90% power with an α risk of 5%.

Independent sample t test for parametric data and Mann-Whitney U test for nonparametric data were used to compare continuous variables between the study and control groups. Repeated-measures analysis was used for within-group comparisons of continuous variables. Fisher's exact test and Pearson χ^2 test were used to compare categorical variables in our study. Statistical significance was defined as a P value of less than .05.

All statistical analyses were performed using SPSS Statistics version 23 (SPSS, Inc, an IBM Company, Chicago, IL).

Results

Clinical Outcomes

The preoperative scores were similar in both groups. Both groups showed significant improvement in the clinical outcomes at the 6- and 24-month follow-up. There was no significant difference in clinical outcomes compared between both groups ($P > .05$) (Table 2). However, the percutaneous

Table 2. Clinical Outcomes.[a]

Outcome Measure/ Time Frame	Percutaneous, Mean ± SD	Open, Mean ± SD	P Value
Visual analog scale			
Preoperative	4.0 ± 2.9	4.9 ± 2.6	.124
Perioperative	1.9 ± 0.6	3.9 ± 1.0	**<.001**
6 months	0.7 ± 1.8	0.9 ± 1.8	.572
24 months	0.7 ± 1.9	0.4 ± 1.5	.620
AOFAS score (hallux)			
Preoperative	58.6 ± 16.6	53.2 ± 14.6	.127
6 months	85.6 ± 14.9	82.7 ± 14.5	.183
24 months	87.4 ± 17.8	88.4 ± 13.8	.547
SF-36 Physical Function Subscale			
Preoperative	76.2 ± 21.8	82.2 ± 19.3	.264
6 months	74.0 ± 28.5	83.9 ± 14.1	.323
24 months	83.1 ± 22.3	82.5 ± 20.1	.525
SF-36 Mental Health Subscale			
Preoperative	78.6 ± 17.6	85.9 ± 11.9	.096
6 months	85.2 ± 14.9	84.5 ± 13.6	.765
24 months	84.8 ± 14.9	85.9 ± 15.3	.676

Abbreviations: AOFAS, American Orthopaedic Foot & Ankle Society; SD, standard deviation; SF-36, Short Form 36.
[a]Boldface indicates statistical significance (*P* < .05).

Table 3. Patient Satisfaction Rate.

Time Frame	Percutaneous, %	Open, %	P Value
6 months	75.9	76.8	.924
24 months	82.8	81.0	.845

group demonstrated less pain during the perioperative period compared with the open group (*P* < .001). In the percutaneous group, the AOFAS score improved from a mean score of 58.6 to 87.4, the VAS score improved from a mean score of 4.0 to 0.7, the SF-36 Physical Function Subscale (PCS) improved from a mean score of 76.2 to 83.1, and the SF-36 Mental Function Subscale (MCS) improved from a mean score of 78.6 to 84.8. In the open group, the AOFAS score improved from a mean score of 53.2 to 88.4, the VAS score improved from a mean score of 4.9 to 0.4, the SF-36 PCS improved from a mean score of 82.2 to 82.5, and the SF-36 MCS improved from a mean score of 85.9 to 85.9. In the percutaneous group and open groups, patient satisfaction was 82.8% and 81%, respectively, at the 24-month follow-up (Table 3).

Radiological Outcomes

Both groups showed significant improvement in the HVA and IMA at the 24-month follow-up (Table 4). In the percutaneous group, the mean HVA improved from preoperative 29.9 ± 8.5 degrees to postoperative 8.8 ± 5.9 degrees. In the open group, the mean HVA improved from preoperative 30.6 ± 8.4 degrees to postoperative 13.8 ± 7.6 degrees (Table 4). The percutaneous group showed significant improvement of HVA compared with the open group (*P* = .023).

Table 4. Radiological Outcomes.[a]

Outcome/Time Frame	Percutaneous, Mean ± SD, deg	Open, Mean ± SD, deg	P Value
Hallux valgus angle			
Preoperative	29.9 ± 8.5	30.6 ± 8.4	.702
24 months	8.8 ± 5.9	13.8 ± 7.6	**.003**
Difference	21.0 ± 7.2	16.8 ± 9.1	**.023**
Intermetatarsal angle			
Preoperative	14.6 ± 3.9	14.6 ± 3.3	.954
24 months	10.3 ± 3.1	8.8 ± 3.4	.055
Difference	4.3 ± 2.9	5.8 ± 3.6	.054

Abbreviation: SD, standard deviation.
[a]Boldface indicates statistical significance (*P* < .05).

Table 5. Perioperative Outcomes and Complications.[a]

Characteristic	Percutaneous	Open	P Value
Operative time, mean ± SD, min	44.3 ± 6.1	56.6 ± 11.8	**<.001**
Fluoroscopic time, mean ± SD, s	44.6 ± 5.9	8.9 ± 3.7	**<.001**
Complications	None	3 wound complications	

Abbreviation: SD, standard deviation.
[a]Boldface indicates statistical significance (*P* < .05).

The mean IMA in the percutaneous group improved from preoperative 14.6 ± 3.9 degrees to postoperative 10.3 ± 3.1 degrees. In the open group, the mean IMA improved from preoperative 14.6 ± 3.3 degrees to postoperative 8.8 ± 3.4 degrees. The improvement in IMA between the 2 groups was comparable (*P* = .054).

Perioperative Outcomes and Complications

In the percutaneous group, the length of operation was significantly shorter than the open group (*P* < .001). However, the average fluoroscopic time was significantly longer in the percutaneous group compared with the open group (*P* < .001). There were 3 wound complications in the open group that required readmissions, and all underwent wound debridement and intravenous antibiotics. No wound complications were reported in the percutaneous group. There was no avascular necrosis, recurrence, nonunion, or dorsal malunion of the distal fragment reported in either group (Table 5).

Discussion

This retrospective study demonstrated that the clinical and radiological outcomes of PECA osteotomies and open scarf–Akin osteotomies were comparable at the 2-year follow-up. However, the percutaneous group experienced less pain during the early postoperative period. In addition, the percutaneous group also demonstrated shorter length of operation and less risk of wound complications compared with the open group.

Hallux valgus is a common forefoot deformity. Patients who are symptomatic and have failed nonoperative management are candidates for surgery. The main aim of the surgery is to relieve the pain by correcting the bony deformity or soft tissue tension.[12] The type of operative procedure is usually based on the severity of radiological parameters, namely, the HVA and IMA. Traditionally, hallux valgus corrective surgeries are performed open, and this technique has demonstrated good clinical and radiological outcomes. However, this approach usually requires extensive soft tissue dissection. Patients may have delayed recovery as a result of postoperative pain, swelling, wound infection, and stiffness.[4,8,13,27]

For the past 2 decades, MIS has become more popular as this technique is able to achieve similar clinical and radiological results and less soft tissue trauma compared with traditional open methods, resulting in faster recovery, less postoperative complications, and shorter duration of hospital stay.[24,29] The first-generation percutaneous technique was introduced by Stephen Isham in the 1980s,[15] and the second-generation percutaneous hallux valgus surgery was the Bosch osteotomy, which is a modification of the Hohmann osteotomy.[5] This technique was subsequently modified and popularized by Giannini and colleagues,[14] who called this the simple, effective, rapid, inexpensive (SERI) technique. Despite the reported good clinical outcomes, one of the major concerns regarding the first- and second-generation technique is the lack of stable internal fixation. Kadakia et al,[17] who conducted a prospective study to evaluate the short-term outcomes of percutaneous distal metatarsal osteotomy for hallux valgus, reported the technique to be associated with an unacceptable rate of complications, specifically recurrence (38%), dorsal malunion (69%), and osteonecrosis.

In view of these disadvantages, Vernois and Redfern[32] developed the minimally invasive chevron and Akin (MICA) technique. This third-generation percutaneous hallux valgus surgery is based on the Association for Osteosynthesis principle, and headless compression screws are used to produce stable internal fixation.[32] There are a few publications reporting the short-term to midterm clinical and radiological outcomes of MICA techniques.[18,23,32] All the studies concluded that the MICA technique is an effective approach for operative management of hallux valgus. Most of these studies reported no major complications, except Lucas y Hernandez et al,[23] who reported the midterm result of the MICA technique. In this series, there were 4 cases of screw removal, 1 case of fixation failure, and 1 case of delayed wound healing. However, all these studies lack a comparison control group to further assess the feasibility of this new technique.

Two recently published comparative studies by Lee et al[20] and Brogan et al[6] have reported comparable clinical and radiological outcomes when comparing the MICA technique with the traditional open approach. Lee et al[20] conducted a prospective, randomized study showing both groups had significant improvement in AOFAS Hallux MTP-IP scores after surgery (PECA group: 61.8-88.9; open scarf/akin osteotomies group: 57.3-84.1; $P = .560$) with comparable final scores. The radiological outcomes are comparable between both groups. However, the PECA group showed significantly lower pain level (VAS) in the early postoperative phase (postoperative day 1 to postoperative week 6,$P < .001$ and $P = .004$, respectively). No serious complications were reported in either group. However, the study only reported the outcomes up to the 6-month follow-up.[20] A study by Brogan et al,[6] which consisted of 81 consecutive cases (49 MIS and 32 open distal chevron osteotomies), also reported similar clinical and radiological outcomes at the 2-year follow-up.

In this study, both groups demonstrated comparable clinical and radiological outcomes at the 2-year follow-up. This is consistent with the findings in previous studies.[6,20] However, the percutaneous group showed a significantly better pain (VAS) score during the perioperative period, which is similar to the result in Lee et al.[20] In addition, the percutaneous group also demonstrated no wound complications and significantly better HVA correction compared with the open group. Lee et al[20] showed improvement in HVA and IMA from the mean preoperative values of 31 and 16 degrees to 8 and 6 degrees, respectively, while Brogan et al[6] showed that the HVA improved in all patients from a preoperative mean of 27 to 10 degrees and IMA improved from 12 to 7 degrees. Similarly, in our study, the HVA and IMA were significantly improved from 29.9 and 14.6 degrees to 8.8 and 10.3 degrees, respectively.

Although percutaneous hallux valgus surgery has shown to be an effective operative technique, this technique is not without complications and is associated with a steep learning curve. Bauer et al[2] reported that the Reverdin-Isham technique could achieve good 2-year AOFAS score improvements and 89% satisfaction rates. However, the study also reported complications such as shortening of the first metatarsal and an elevated risk of first metatarsophalangeal joint noncongruency. A prospective study by Kadakia et al,[17] which evaluated the SERI technique, reported a high number of complications such as dorsal malunion (70%), recurrence (40%), osteonecrosis, and wound complications, so the study was abandoned eventually. In our study, no complications were reported in the percutaneous group at the 2-year follow-up, but 3 wound complications were noted in the open group. We postulated that the percutaneous technique used an extracapsular approach, allowing minimal disruption of the overlying periosteum and medullary cavity, thus preserving the blood supply to the metatarsal head and preventing avascular necrosis. The reported incidences of skin burning from the burr have ranged from 0% to 13%.[9,10] In this study, we used a high-torque, low-speed burr to reduce the risk of thermal damage to the bone. Hence, no portal burn complication was reported in our study. To prevent complications and minimize the learning curve, cadaveric training is important for any surgeon considering performing minimally invasive operative techniques.[27]

The strengths of this study include being the first to compare the clinical and radiological outcomes of PECA osteotomies with open scarf–Akin osteotomies at the 2-year follow-up. In addition, we believe this is also the first comparative study reporting the outcomes of the PECA osteotomy technique in an Asian population.

The study is not without its limitations. First, this is a retrospective comparative study, and future large randomized control trials are warranted. The study may have been limited by small sample size, but this was a matched paired study, and power analysis for the sample size was performed.

Conclusion

In conclusion, third-generation percutaneous hallux valgus surgery was able to achieve comparable clinical and radiological results compared with an open procedure at the 2-year follow-up. It also resulted in significantly less perioperative pain, shorter length of operation, and less risk of wound infections.

Declaration of Conflicting Interests

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