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# Scarf versus long chevron osteotomies for the treatment of hallux valgus: A prospective randomized controlled study

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ABSTRACT

*Background:* The aim of this study is to compare scarf osteotomy and long chevron osteotomy in treatment of hallux valgus deformity regarding operative time, power of correction and complications.
*Design:* A prospective randomized controlled comparative trial.
*Methods:* 48 cases with hallux valgus were divided randomly in 2 groups (21 treated by scarf and 22 treated by long chevron osteotomy and 5 were missed during follow up), average age 36 years, follow up time was average of 25.9 months. Patients were assessed clinically, radiologically, and functional scoring system of American College of Foot and ankle Surgeons (ACFAS)was used both pre and postoperatively.
*Results:* Operative time was 69 min in scarf group compared to 63 min to long chevron group, radiological correction showed no statistically significant difference between both groups while functional improvement in ACFAS score was in favour of long chevron group 69.1% compared to scarf group 57.5%
*Conclusions:* Both osteotomies possess almost identical corrective power of the IMA (intermetatarsal angle) and similar clinical outcomes with slightly shorter operative time and subjective technical simplicity for the long chevron osteotomy.


## 1. Introduction

More than 130 operations have been described for the treatment of hallux valgus. This huge number means that no single procedure can address all cases, and treatment has to be tailored according to each specific patient's needs and peculiarities. Surgery aims not only to the aesthetic correction of the deformity, but also to a functional painless foot.

The scarf osteotomy is a well-established surgery for hallux valgus, however, it is a technically demanding procedure. The conventional 'short' chevron osteotomy [1] is a rather simpler procedure. However, the magnitude of deformity correction is limited [2]. There are also concerns about its healing power and avascular necrosis of the metatarsal head [3,4].

The long 'extended plantar limb' chevron introduced by Mahadevan et al. [5] seems to combine the good of both osteotomies, the simplicity of the chevron with the corrective power and stability of the scarf. The aim of our study is to compare both osteotomies in terms of operative time, functional and radiological outcomes, and complications. Our hypothesis is that long chevron osteotomy combines the good of both worlds in terms of avoiding the complexity of the scarf osteotomy while maintaining the same corrective power.

## 2. Materials and methods

### 2.1. Study design

This is a prospective randomized controlled trial, designed to compare both osteotomies. The study was conducted in our institution, from January 2013 to January 2015, after the approval of the scientific and ethical committee was obtained.

Patients with painful hallux valgus after failed conservative treatment for 6 months with inter-metatarsal angle (IMAs) between 10 up to 20° aged 18 to 80 were included. We excluded patients with MTP arthrosis, rheumatoid arthritis, paralytic hallux valgus, patients not fit for surgery, or patients with lost follow ups.

Power analysis was done using MedCalc® Statistics Software v.15.8 (bvba, Ostend, Belgium), depending on data of previous studies of Bai et al. [6], and Kerr et al. [7]; that estimated a sample

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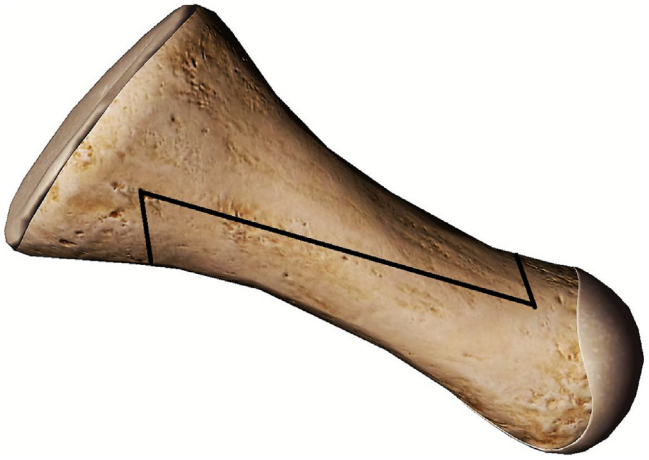

**Fig. 1.** Schematic illustration of scarf osteotomy.

size of 18 subjects for each group. We decided to include at least 24 patients for each group to overcome any lost follow ups, and to reach a stronger evidence.

We included 48 consecutive patients with hallux valgus, whom were randomized using computer generated randomization by Random Allocation Software V.4.5 (Asfahan, IR) into 2 groups: "L-gp" (patients for long chevron osteotomy), and "S-gp" (patients for scarf osteotomy). Patients with hallux interphalangeus invariably required an additional Akin osteotomy in both groups. Informed written consents were obtained from all patients.

### 2.2. Surgical technique

All surgical procedures were conducted using the standard sterilization and draping techniques in the supine position with a tight pneumatic tourniquet. General or regional anesthesia was used.

#### 2.2.1. Incision

Assessment of the mobility the first MTP joint was done under general anesthesia. Initial lateral capsular release with adductor hallucis tenotomy off the lateral sesamoid (modified McBride release) was performed only in cases with limited abduction of first MTP joint. The goal of release was to achieve at least 30° of abduction of first MTP joint prior to osteotomy. In all cases the lateral release was performed through a small lateral incision, neither trans-articular nor via the medial incision to avoid injury of the major blood supply of the head near the plantar aspect of the metatarsal neck [11]. Next, a medial longitudinal skin incision was made over the medial border of the first metatarsal extending from the base of the proximal phalanx to about the 1 cm proximal to the first tarso-metatarsal joint (TMTJ). If akin osteotomy was planned,

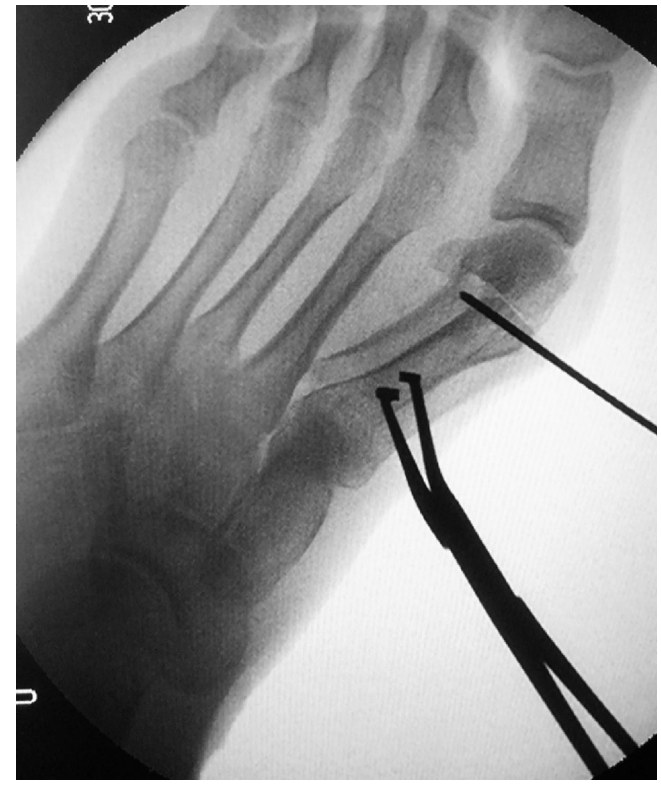

**Fig. 2.** Position being verified by image intensifier.

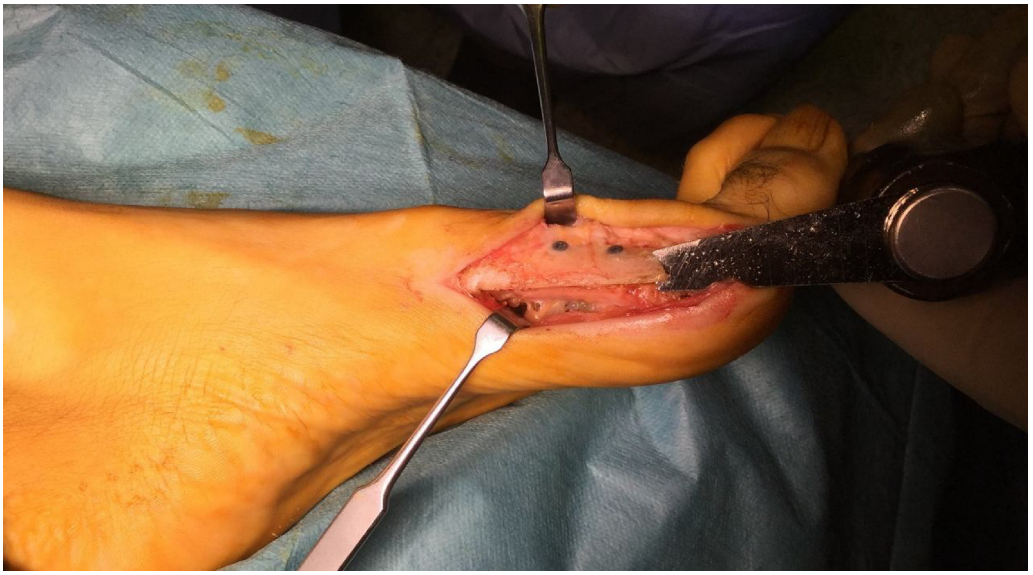

**Fig. 3.** Excision of medial overhang with a power saw.

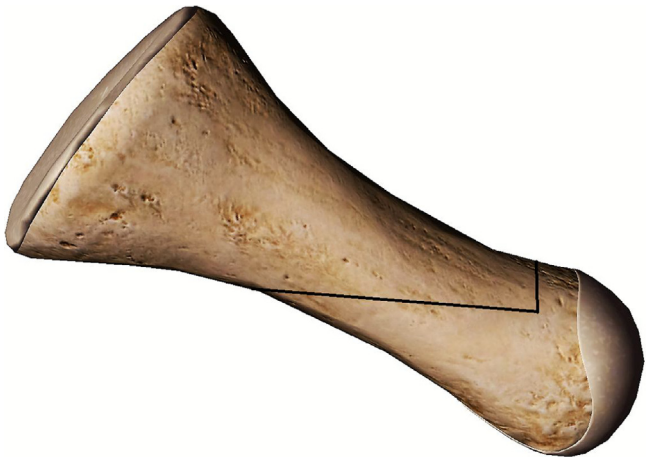

**Fig. 4.** Schematic illustration of the long chevron osteotomy.

distal extension of the incision was done to expose the shaft of the proximal phalanx. Blunt dissection was then carried out avoiding injury of the medial cutaneous nerve. The capsule was incised lengthwise ensuring intact cuff of tissues to perform capsulorrhaphy later. Bunionectomy was performed using a saw just medial to the sulcus. Osteotomy was then performed according to the preoperative plan.

*2.2.2. Scarf osteotomy*

The scarf osteotomy was done according to the technique described by Coetzee and Rippstein [8], starting with marking the osteotomy lines with cautery on the first metatarsal shaft.

In this technique, the proximal corner point of the scarf osteotomy was located at the diaphyseal–metaphyseal junction around 1.5 cm distal to the first TMTJ and 5 mm from the planter cortex. The distal corner point was located 1 cm proximal to the first MTPJ and 5 mm from the dorsal cortex. After cutting the osteotomy with small power saw, translation was then performed and held with two 1 mm k-wires. At this point the image intensifier was used to ensure adequate correction and proper sesamoid position. The osteotomy was then fixed with two screws (2.7 AO or Herbert screws) starting with the distal one and the medial overhang was carefully excised with a saw. Medial capsulorrhaphy was then performed with heavy absorbable sutures and the skin was closed in the standard manner (Figs. 1–3).

*2.2.3. Long chevron osteotomy*

The apex of the osteotomy was centered 3–5 mm superior to the geometric center of the metatarsal head. The dorsal cut was made more vertical than in conventional chevron osteotomy, and it was directed perpendicular to the second metatarsal in the axial plane. The plantar cut was made more horizontal than a traditional chevron resulting in a longer plantar limb, which exits at least 25 mm from the articular surface. The length of the plantar limb was determined according to the desired amount of correction. The longer the plantar limb, the more correction could be achieved in the IMA angle. The osteotomy was displaced medially to correct the IMA. The adequacy of correction was checked by simulating weight bearing on a flat surface and Intraoperative X ray was done to check the position of sesamoids in relation to the first metatarsal. The osteotomy was then fixed using one or two screws (2.7 AO or Herbert screws) (Figs. 4–6).

*2.2.4. Akin osteotomy*

4 cases in each group required additional Akin osteotomy (all of them had IMA $> 20^{\circ}$). The Akin osteotomy was performed as a medial closing wedge and fixed by one 2.7 AO or Herbert screw (Fig. 7).

*2.2.5. Post-operative protocol*

The postoperative protocol was done for both groups of patients (Figs. 5–7). Wrapping of the hallux in corrected position was done using crepe bandage. The patients were allowed weight bearing on metatarsal offloading shoes (Fig. 8) from the second day postoperative. Stitches were removed at 2 weeks post-operative. After 6 weeks patients were allowed to do weightbearing out of the offloading orthosis in a rigid insole. The rigid insole was discarded allowing toe off after 12 weeks. Return to sports was allowed after 6 months. Follow up of the patients was done at 2 weeks, one month, 3 months, 6 months and one-year intervals.

*2.3. Outcome measures*

*2.3.1. Clinical*

The American College of Foot and Ankle Surgeons Scoring Scaling (ACFAS) [9], Module I for first MTP joint and first ray. The scale is a 100-point scale and used to grade patient satisfaction two years after the surgery. Data were collected by personnel other than those who conducted the surgical procedures.

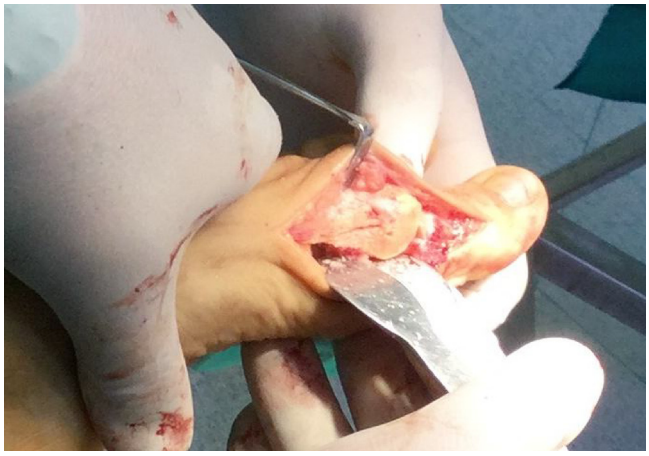

**Fig. 5.** Long chevron osteotomy cuts.

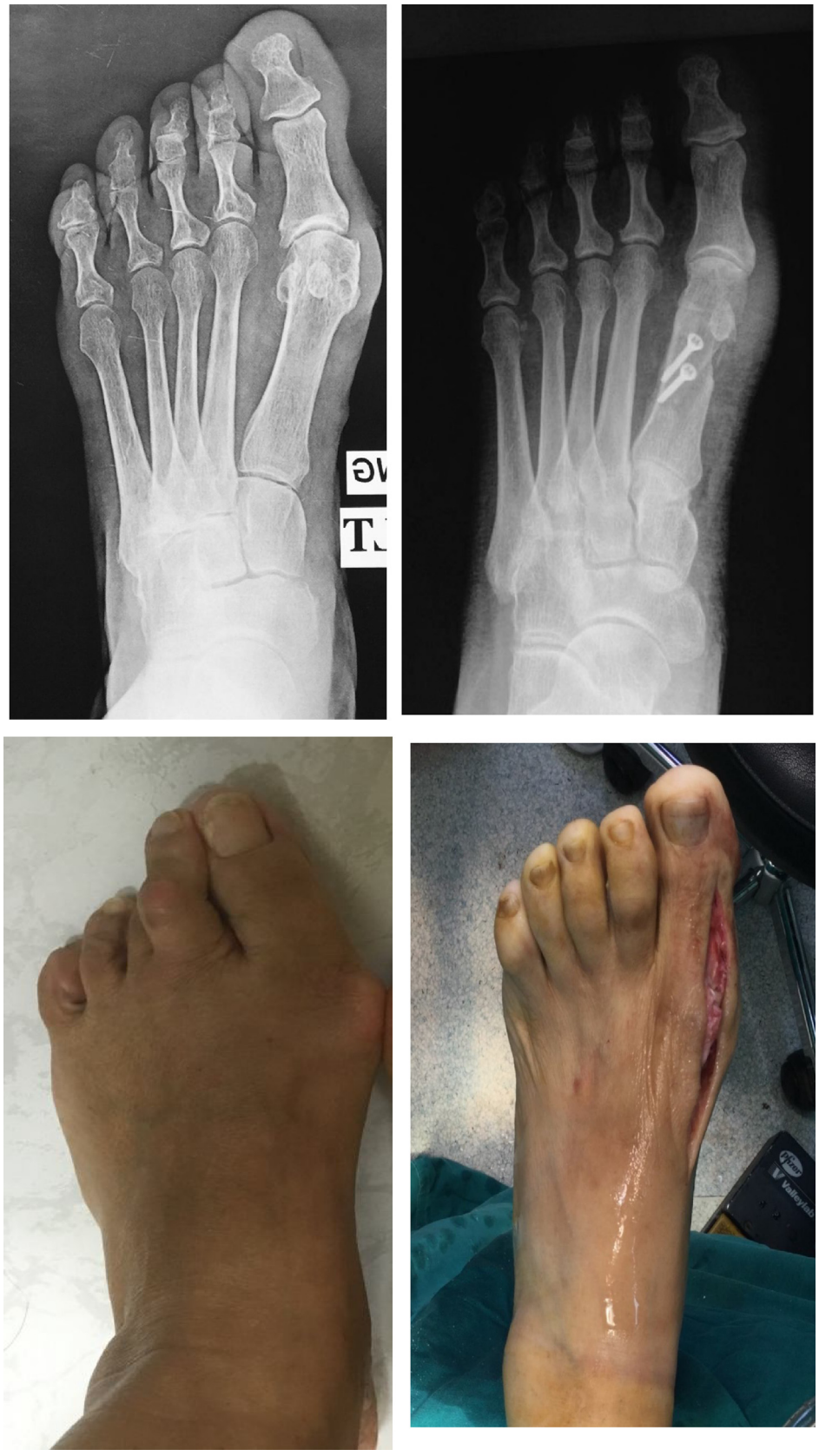

**Fig. 6.** Long chevron case example.

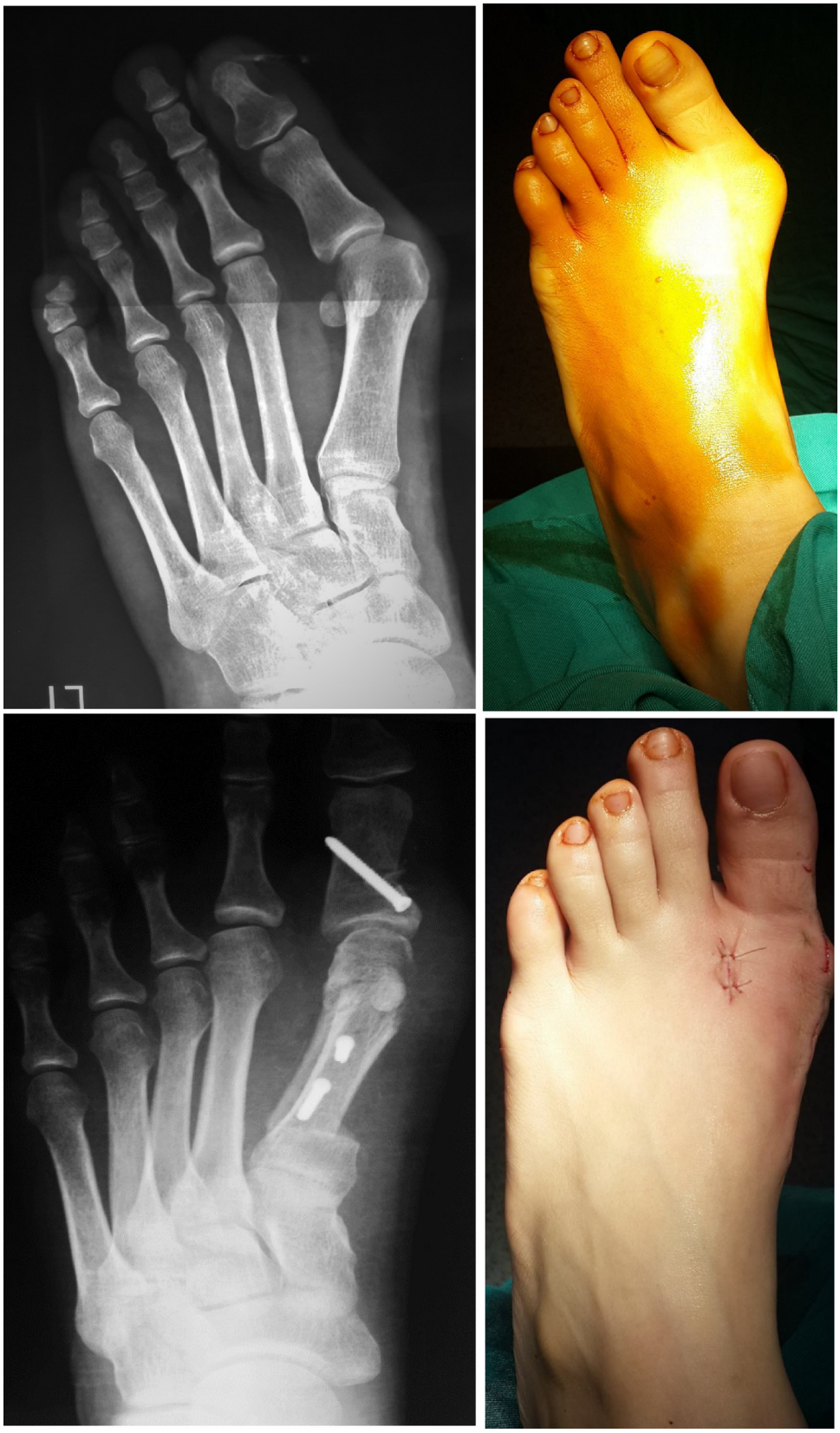

**Fig. 7.** Scarf + Akin osteotomy case example.


**Fig. 8.** Offloading shoes used.

### 2.3.2. Radiological

The weight bearing radiographs two years post-surgery were used to measure; HVA (hallux valgus angle; the angle formed between the long axis of the first metatarsal and the proximal phalanx of the hallux), IMA (Inter-metatarsal angle; the angle formed between the long axes of the first and second metatarsal bones), DMAA (Distal metatarsal articular angle; the angle formed between a line perpendicular to the long axis of the firsts metatarsal and another representing the distal articular surface in the antero-posterior view) & FDMA (First metatarsal declination angle; the angle formed between the long axis of the first metatarsal bone and the horizon in the lateral view). The sesamoid positions were also recorded and any other data e.g., AVN of the metatarsal head, hardware failure or migration, signs of osteomyelitis.

### 2.3.3. Statistical analysis

Analysis done with IBM® SPSS® Statistics software v21 (IBM Corporation, Armonk, NY, USA). Our statistical analysis hinged around two pivots; first we had to analyze the chosen sample for each surgery and verify similar clinical and radiological parameter to avoid selection bias, and second we started analyzing clinical and radiological outcome data as well as other data such as operative time and complications. Scores medians and means were analyzed and compared. Significances were tested using Wilcoxon Signed Ranks Test for related samples, and Mann–Whitney test for independent samples, and Pearsons correlation test for bivariate variables. Results were considered significant at the 95% confidence interval level for all statistical analyses.

**Table 1**
Summary of cases classified according to the IMA severity (S stands for scarf group and L stands for long chevron group).

| | | | Type of procedure | | Total |
|---|---|---|---|---|---|
| | | | Long chevron | Scarf | |
| Preoperative IMA severity | Mild | Count | 1 | 3 | 4 |
| | | Percentage within the procedure S/L | 4.5% | 14.3% | |
| | | Percentage of total | 2.3% | 7.0% | 9.3% |
| | Moderate | Count | 9 | 9 | 18 |
| | | Percentage within the procedure S/L | 40.9% | 42.9% | |
| | | Percentage of total | 20.9% | 20.9% | 41.9% |
| | Severe | Count | 12 | 9 | 21 |
| | | Percentage within the procedure S/L | 54.5% | 42.9% | |
| | | Percentage of total | 27.9% | 20.9% | 48.8% |

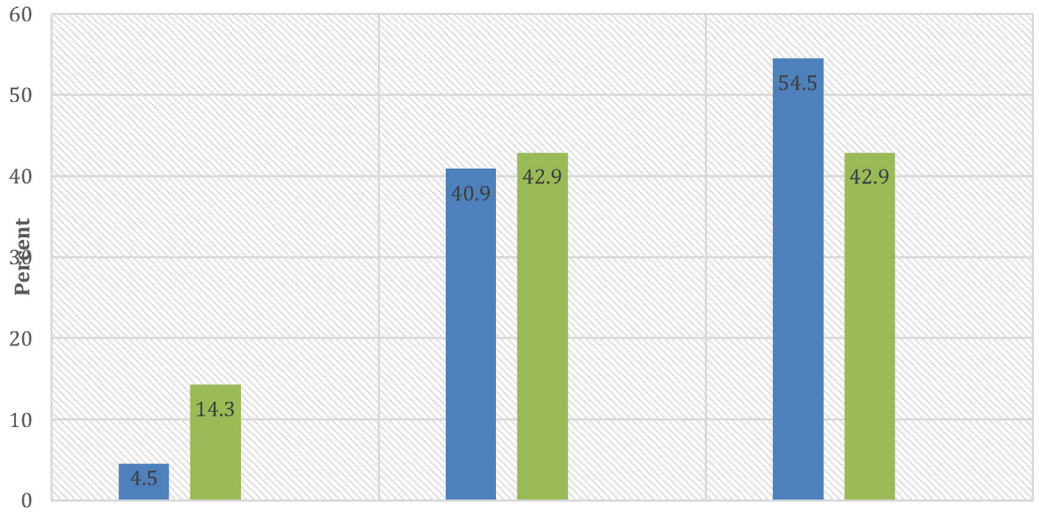


**Fig. 9.** Comparison of the two groups according to IMA severity in percentage.
Mild < 14°.
Moderate 14:20°.
Severe > 20°.

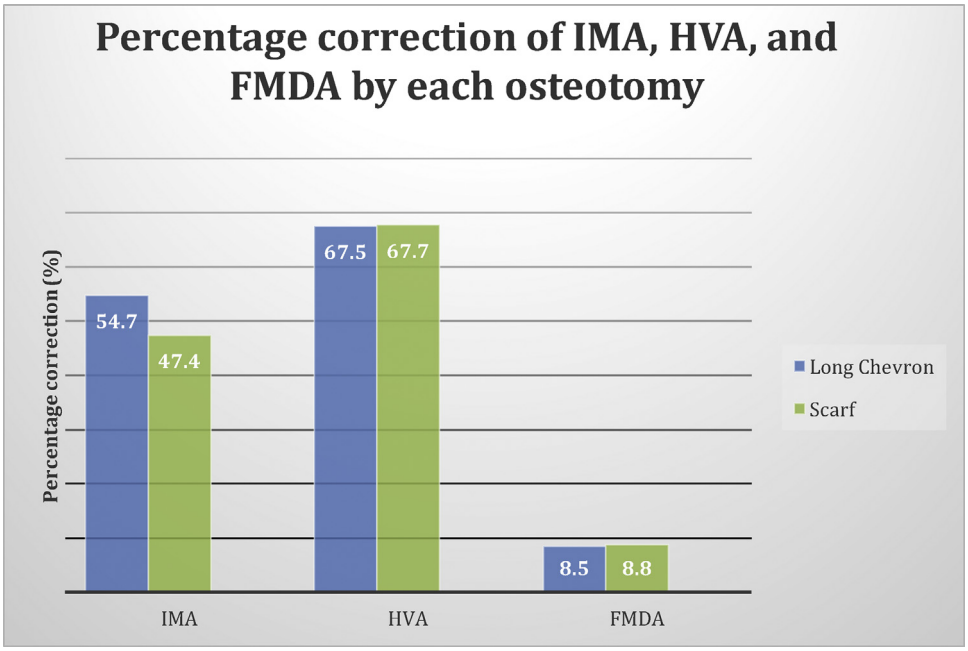


**Fig. 10.** Percentage of radiological correction of each osteotomy (IMA = 1,2 intermetatarsal angle, HVA = hallux valgus angle and FDMA = first metatarsal declination angle).

## 3. Results

### 3.1. Demographic data

A group of 48 patients with hallux valgus were recruited for this study, only 43 patients reached the final follow up (21 in scarf group/22 in long chevron group). The average age was 36, range 18–67 with a standard deviation of 12.16. There were 19 male and 24 female cases. 22 of the feet were right and 21 were left. The average duration of symptoms was 31 months, range 12–60 with a standard deviation of 10.53. 4 cases in each group required additional Akin osteotomy (all of them had IMA > 20°)

5 patients did not attend the follow-up visits in the scheduled intervals. All attempts at contacting the patients failed. They were excluded from the study.

### 3.2. Operative time

The mean operative time for scarf group was 69 min, range 55–90 with a standard deviation of 8.38, compared to 63, range 45–80 min with a standard deviation of 8.36 for long chevron group with a P-value of 0.86

### 3.3. Radiological outcomes

#### 3.3.1. Preoperative IMA comparison

The study included 4 mild (IMA < 14°) cases according to the severity of IMA (3 in scarf group/1 in long chevron group), 18 moderate (IMA 14:20°) cases (9 patients in each group), and 21 severe (IMA > 20°) cases (9 in scarf group/12 in long chevron group). These data show almost a uniform sample of selected cases per osteotomy. Table 1 and Fig. 9 summarize spectrum of cases according to IMA severity.

#### 3.3.2. Post-operative radiological outcomes

Radiological parameter analysis of the two samples showed almost identical post-operative results in terms of IMA, HVA and FDMA (Fig. 10). The P-value of this data is not low enough to make it statistically significant (Tables 2 and 3).

### 3.4. Patient — reported outcomes

#### 3.4.1. Follow-up period

The mean follow-up period was 25.9 + 1.84 months (range 24–30).

#### 3.4.2. ACFAS score analysis

The mean preoperative ACFAS score for the long chevron group was 48.36 out of 100 (9.08 SD 'Standard deviation'), compared to 50.85 (9.59 SD) for the scarf group.

The average ACFAS score change in percentage was 69.1% for the long chevron group compared to 57.5% for the scarf group with a (P-value of 0.29)

**Table 2**
Comparison between preoperative and postoperative values of IMA, HVA and FDMA. Note that there are no significant differences between the two techniques.

| | Parameter | Long chevron | Scarf | T-test | P-value |
|---|---|---|---|---|---|
| Pre-op data | IMA | 20.36 ± 3.54 | 18.48 ± 4.50 | 0.52 | 0.140 |
| | HVA | 32.5 ± 12.81 | 34.81 ± 13.42 | 0.57 | 0.57 |
| | FMDA | 20.96 ± 2.42 | 21.14 ± 3.00 | 0.23 | 0.82 |
| Post-op data | IMA | 9.10 ± 2.31 | 9.24 ± 2.98 | 0.18 | 0.86 |
| | HVA | 8.91 ± 1.80 | 10.10 ± 5.16 | 0.10 | 0.33 |
| | FMDA | 19.00 ± 2.29 | 19.00 ± 2.10 | 0 | 1 |

**Table 3**
Comparison of the 2 osteotomies in terms of amount and percentage of radiological correction.

| | Long chevron | Scarf | T-test | P-value |
|---|---|---|---|---|
| IMA correction | 11.27 ± 3.41 | 9.24 ± 5.22 | 0.51 | 0.14 |
| Percent correction | 54.65 ± 12.87 | 47.40 ± 18.45 | 0.49 | 0.15 |
| HVA correction | 23.64 ± 12.86 | 24.71 ± 11.96 | 0.28 | 0.78 |
| Percent correction | 67.52 ± 16.64 | 67.65 ± 16.75 | 0.03 | 0.98 |
| FMDA correction | 1.95 ± 2.89 | 2.14 ± 2.95 | 0.21 | 0.83 |
| Percent correction | 8.48 ± 13.28 | 8.82 ± 13.47 | 0.08 | 0.93 |

**Table 4**
Relationship between post-operative clinical and radiological data in relation to the preoperative IMA severity.

| | | N | Mean | Std. deviation | Std. error | 95% confidence interval for mean | | Minimum | Maximum | Pearson's correlation | P-value |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Lower bound | Upper bound | | | | |
| Post-op ACFAS score/100 | Mild | 4.0 | 76.5 | 6.0 | 3.0 | 67.0 | 86.0 | 70.0 | 84.0 | −0.007 | 0.966 |
| | Moderate | 18.0 | 79.1 | 8.6 | 2.0 | 74.8 | 83.4 | 68.0 | 97.0 | | |
| | Severe | 21.0 | 77.9 | 7.3 | 1.6 | 74.6 | 81.2 | 63.0 | 90.0 | | |
| | Total | 43.0 | 78.3 | 7.7 | 1.2 | 75.9 | 80.6 | 63.0 | 97.0 | | |
| Post-op pain | Mild | 4.0 | 24.0 | 4.0 | 2.0 | 17.6 | 30.4 | 22.0 | 30.0 | −0.132 | 0.400 |
| | Moderate | 18.0 | 26.9 | 4.0 | 0.9 | 24.9 | 28.9 | 22.0 | 30.0 | | |
| | Severe | 21.0 | 24.7 | 3.9 | 0.8 | 22.9 | 26.4 | 22.0 | 30.0 | | |
| | Total | 43.0 | 25.5 | 4.0 | 0.6 | 24.3 | 26.8 | 22.0 | 30.0 | | |
| Post-op appearance | Mild | 4.0 | 3.5 | 1.0 | 0.5 | 1.9 | 5.1 | 3.0 | 5.0 | 0.127 | 0.416 |
| | Moderate | 18.0 | 4.1 | 0.9 | 0.2 | 3.6 | 4.5 | 3.0 | 5.0 | | |
| | Severe | 21.0 | 4.1 | 0.8 | 0.2 | 3.8 | 4.5 | 3.0 | 5.0 | | |
| | Total | 43.0 | 4.0 | 0.9 | 0.1 | 3.8 | 4.3 | 3.0 | 5.0 | | |
| Post-op functional capacity | Mild | 4.0 | 8.8 | 2.5 | 1.3 | 4.8 | 12.7 | 5.0 | 10.0 | −0.101 | 0.519 |
| | Moderate | 18.0 | 10.3 | 4.0 | 0.9 | 8.3 | 12.3 | 5.0 | 15.0 | | |
| | Severe | 21.0 | 8.6 | 3.2 | 0.7 | 7.1 | 10.0 | 5.0 | 15.0 | | |
| | Total | 43.0 | 9.3 | 3.5 | 0.5 | 8.2 | 10.4 | 5.0 | 15.0 | | |
| Subjective post-op ACFAS/50 | Mild | 4.0 | 40.3 | 4.1 | 2.1 | 33.7 | 46.8 | 35.0 | 44.0 | 0.137 | 0.38 |
| | Moderate | 18.0 | 37.8 | 5.7 | 1.4 | 35.0 | 40.7 | 25.0 | 47.0 | | |
| | Severe | 21.0 | 40.5 | 4.9 | 1.1 | 38.3 | 42.8 | 31.0 | 47.0 | | |
| | Total | 43.0 | 39.4 | 5.3 | 0.8 | 37.7 | 41.0 | 25.0 | 47.0 | | |
| Postop HVA | Mild | 4.0 | 5.3 | 1.5 | 0.8 | 2.9 | 7.6 | 3.0 | 6.0 | 0.245 | 0.113 |
| | Moderate | 18.0 | 6.0 | 0.0 | 0.0 | 6.0 | 6.0 | 6.0 | 6.0 | | |
| | Severe | 21.0 | 6.0 | 0.0 | 0.0 | 6.0 | 6.0 | 6.0 | 6.0 | | |
| | Total | 43.0 | 5.9 | 0.5 | 0.1 | 5.8 | 6.1 | 3.0 | 6.0 | | |
| Postop FMDA | Mild | 4.0 | 6.0 | 0.0 | 0.0 | 6.0 | 6.0 | 6.0 | 6.0 | 0.017 | 0.915 |
| | Moderate | 18.0 | 5.8 | 0.9 | 0.2 | 5.3 | 6.2 | 2.0 | 6.0 | | |
| | Severe | 21.0 | 6.0 | 0.0 | 0.0 | 6.0 | 6.0 | 6.0 | 6.0 | | |
| | Total | 43.0 | 5.9 | 0.6 | 0.1 | 5.7 | 6.1 | 2.0 | 6.0 | | |
| Post-op paper-pull out test | Mild | 4.0 | 8.8 | 2.5 | 1.3 | 4.8 | 12.7 | 5.0 | 10.0 | 0.025 | 0.876 |
| | Moderate | 18.0 | 7.8 | 2.6 | 0.6 | 6.5 | 9.0 | 5.0 | 10.0 | | |
| | Severe | 21.0 | 8.3 | 2.4 | 0.5 | 7.2 | 9.4 | 5.0 | 10.0 | | |
| | Total | 43.0 | 8.1 | 2.4 | 0.4 | 7.4 | 8.9 | 5.0 | 10.0 | | |
| Post-op dorsiflexion | Mild | 4.0 | 4.0 | 3.3 | 1.6 | -1.2 | 9.2 | 0.0 | 8.0 | 0.147 | 0.347 |
| | Moderate | 18.0 | 2.9 | 3.0 | 0.7 | 1.4 | 4.4 | 0.0 | 8.0 | | |
| | Severe | 21.0 | 4.6 | 3.2 | 0.7 | 3.1 | 6.0 | 0.0 | 8.0 | | |
| | Total | 43.0 | 3.8 | 3.1 | 0.5 | 2.8 | 4.8 | 0.0 | 8.0 | | |
| Post-op MTP plantar flexion | Mild | 4.0 | 4.0 | 0.0 | 0.0 | 4.0 | 4.0 | 4.0 | 4.0 | 0.057 | 0.714 |
| | Moderate | 18.0 | 3.3 | 1.5 | 0.4 | 2.6 | 4.1 | 0.0 | 4.0 | | |
| | Severe | 21.0 | 3.6 | 1.2 | 0.3 | 3.1 | 4.2 | 0.0 | 4.0 | | |
| | Total | 43.0 | 3.5 | 1.3 | 0.2 | 3.1 | 3.9 | 0.0 | 4.0 | | |
| Post-op IPJ extension | Mild | 4.0 | 2.0 | 0.0 | 0.0 | 2.0 | 2.0 | 2.0 | 2.0 | 0.078 | 0.435 |
| | Moderate | 18.0 | 2.0 | 0.0 | 0.0 | 2.0 | 2.0 | 2.0 | 2.0 | | |
| | Severe | 21.0 | 2.0 | 0.0 | 0.0 | 2.0 | 2.0 | 2.0 | 2.0 | | |
| | Total | 43.0 | 2.0 | 0.0 | 0.0 | 2.0 | 2.0 | 2.0 | 2.0 | | |
| Post-op limp on walking | Mild | 4.0 | 5.0 | 0.0 | 0.0 | 5.0 | 5.0 | 5.0 | 5.0 | 0.093 | 0.553 |
| | Moderate | 18.0 | 4.7 | 1.2 | 0.3 | 4.1 | 5.3 | 0.0 | 5.0 | | |
| | Severe | 21.0 | 5.0 | 0.0 | 0.0 | 5.0 | 5.0 | 5.0 | 5.0 | | |
| | Total | 43.0 | 4.9 | 0.8 | 0.1 | 4.6 | 5.1 | 0.0 | 5.0 | | |

Table 4 illustrates Relationship between post-operative clinical and radiological data in relation to the preoperative IMA severity

### 3.5. Summary of results

Both osteotomies have demonstrated nearly identical clinical outcome scores. The main radiological angles of both osteotomies were similar, for example the mean post-operative IMA of the long chevron group was $9.10 \pm 2.31^{\circ}$ versus $9.24 \pm 2.98$ for the scarf group (p-value = 0.86) and the HVA was $8.91 \pm 1.80^{\circ}$ versus $10.10 \pm 5.16$ for the scarf group (p-value = 0.33).

### 3.6. Complications

We had one superficial infection that resolved with antibiotic therapy in both groups, one wound dehiscence per group and one case of recurrence in the long chevron group due to a technical error of unintended valgus angulation during translation of the

**Table 5**
Summary of complications.

| | Scarf | Long chevron |
|---|---|---|
| Infection | 1 (superficial) | 1 (superficial) |
| Hardware failure | 0 | 0 |
| Non-union | 0 | 0 |
| AVN | 0 | 0 |
| Wound dehiscence | 1 | 1 |
| Recurrence | 0 | 1 |

capital fragment leading to alteration of the DMAA. Table 5 summarizes complications.

## 4. Discussion

This study has shown that both osteotomies have nearly similar clinical and radiological outcomes and corrective power. However, the technical simplicity reported subjectively by the surgeons performing both osteotomies and shorter operative time favor the long chevron osteotomy. Having a single transverse cut allows combined angulation and translation of the distal end of the bone which offsets its smaller contact surface compared to the scarf. Single screw fixation was possible in the long chevron osteotomy with most scarf osteotomies requiring double screw fixation.

Sagittal plane angulation is another problem with the scarf osteotomy where the cortical ends deeply imbed themselves into the cancellous bone on both ends resulting, mostly, in elevation of the capital fragment which does not happen with the long chevron osteotomy due to presence of cortex-on-cortex contact proximally despite any degree of displacement [5].

Clinical outcome scores and patient satisfaction surveys revealed no statistically significant differences. We used written questionnaires as well as verbal questioning of the quality of life parameters.

Interestingly, we have found a correlation of favorable postoperative parameters with less severe preoperative IMAs. However, this correlation was not statistically significant due to the relatively small sample sizes (Table 4).

Mahadevan et al. [5] have conducted a similar RCT on 84 patients (109 feet) with encouraging results in favor of the long chevron osteotomy (significantly lower IMA 5.8 versus 6.9 p-value 0.045 and similar other radiological and clinical parameters).

Vopat et al. [10] have conducted a retrospective comparative study between the scarf and long chevron osteotomies on 70 patients. There were no statistically significant differences between the two osteotomies regarding the HVA pre-operatively and post-operatively. The DMAA was statistically significantly higher for the long chevron both preoperatively ($p = 0.0403$) and postoperatively ($p < 0.0001$). The differences in HVA correction and IMA correction were not statistically significant. There were no statistically significant differences with regard to post-operative stiffness, pain, and satisfaction.

One limitation of our study was that surgeries were performed by more than one surgeon. We did our best to standardize the procedure and each surgeon did equal number of cases per group. It can be argued that performing the study be more than one surgeon adds to its strength to negate the effect of personal bias and previous experiences. It is also notable that the two main surgeons who performed the procedures had the same level of experience (more than 10 years of foot and ankle surgery) and the other surgeons were assistants and participated in data collection. Another short-coming of our study is the, relatively, short-term follow-up of patients. Longer term studies are needed to fortify the results of the study.

## 5. Conclusion

We have found out that the two osteotomies possess almost identical corrective power of the IMA and similar clinical outcomes with slightly shorter operative time and subjective technical simplicity for the long chevron osteotomy.

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## Conflict of interest

All authors declare that they have no conflict of interest.

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