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Case Series

# Modified Mitchell technique for treating hallux valgus: Retrospective case series on a Middle-Eastern population and literature review

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ABSTRACT

*Introduction:* The hallux valgus deformity is a complex deformity of the first ray of the foot, with more than 100 procedures developed for its treatment. The aim of this retrospective study was to assess the clinical and radiographic outcomes of a modified Mitchell's technique.

*Methods:* Between 2007 and 2018, 75 patients underwent the procedure. Clinical results were assessed by the AOFAS score. Radiological studies were evaluated by measuring pre-operative and post-operative HVA and IMA angles as well as the relative shortening of the first metatarsal.

*Results:* Of the initial 75 patients, 42 patients remained eligible with a total of 67 feet. The mean age and follow-up were 47.8 and 5.2 years respectively. Global AOFAS score improved from 45.3 to 88.8 ($p < 0.01$). Mean HVA and IMA improved from 37.0 to 10.2 ($p < 0,01$) and 12.1 to 5.6 ($p < 0.01$), respectively. The mean metatarsal shortening was 3.0 mm ($p < 0.01$). The statistical analysis showed no significant correlation between preoperative HVA and IMA angles with postoperative shortening, metatarsalgia, AOFAS scores nor the difference between the preoperative and postoperative AOFAS scores.

*Conclusion:* Short- and long-term outcomes of this modified Mitchell's osteotomy have been reported. Compared to other studies, these modifications proved to result in very good clinical and radiological outcomes even in severe cases with HVA>40. It has shown to be reliable, reproducible, and cost-efficient with low complication rates. We would like to highlight the importance of proper patient selection, limited soft tissue stripping, and adherence to the proposed surgical steps to avoid unwanted complications.

## 1. Introduction

The term hallux valgus refers to the combination of medial deviation of the first metatarsal associated with a medial bony and soft tissue prominence, and lateral deviation of the hallux [1]. It is a complex first ray deformity with presence of an imbalance of the adductor and abductor muscles, rotation of the hallux, anomalous foot mechanics that largely occurs in populations who wear shoes and that is rarely seen in populations that are mostly barefoot [1–3].

There are currently more than 100 surgical procedures for the treatment of hallux valgus which is due to the fact that it is a complex deformity with no uniformly ideal procedure, and the optimal treatment needs to be decided on a case by case basis by assessing the appearance and the degree of the deformity [4].

Mitchell's procedure, which consists of a double step-cut osteotomy at the level of the first metatarsal neck was first described in 1945 by Hawkins, is one of the most commonly used distal metatarsal osteotomies, and multiple modifications to the original technique have been proposed since its original inception to avoid the encountered complications of this technique [5]. Some of the well-known complications include transfer metatarsalgia, malunion, nonunion, recurrent deformity, and avascular necrosis of the first metatarsal head [6].

The aim of this retrospective study was to assess the clinical and radiographic outcomes of the modified Mitchell's technique in a Middle-

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Eastern population. To note, this study is in compliance with PROCESS guidelines [7].

## 2. Patients & methods

Between November 2007 and August 2018, 75 patients underwent a modified Mitchell technique for treatment of their hallux valgus deformity. All of the procedures were conducted by one surgeon in a single institution. Patients who had a diagnosis of rheumatoid arthritis, neuromuscular diseases, underwent prior forefoot surgeries, presented with first ray hypermobility or were younger than 18 were excluded from this study.

Indications for surgical treatment were failed conservative treatment of at least six months duration, with forefoot pain and HVA (hallux valgus angle) > 20. A HVA> 40 was not considered a surgical contraindication to undergoing this modified technique, and patients with osteoarthritis of the first metatarsophalangeal joint or with an IMA (inter-metatarsal angle) > 20 were treated by a different surgical procedure. Patients with a significantly short first metatarsal (Greek foot) with callosities identified under the heads of the lesser metatarsals were also treated by a different surgical technique.

Clinical outcomes were assessed by the use of the American Orthopedic Foot and Ankle Society (AOFAS) Hallux Metatarsophalangeal-Interphalangeal score pre-operatively and post-operatively at the latest follow up [8]. This 100-point evaluation system works with three main parameters: pain (40 points); function (45 points) and alignment (15 points). This particular clinical scoring system was and is widely used in the literature.

Radiographic assessment was conducted on standard anteroposterior and lateral weight-bearing radiographs. All of the radiological measurements were estimated by a radiologist. The HVA was determined by bisecting the shafts of the first proximal phalanx and of the first metatarsal [9]. Hardy & Clapham stated that the IMA should be determined by bisecting the shafts of the first and second metatarsals [10]. Postoperatively, the IMA measurement was modified to account for the surgical displacement of the first metatarsal head by measuring the angle formed by the diaphyseal axis of the second metatarsal and a line joining the center of the laterally displaced first metatarsal head with the center of the first metatarsal base [11].

The proportional postoperative shortening of the first metatarsal compared to the second metatarsal was measured as the change in the distance between the midpoint of distal articular surfaces of the first and second metatarsals [2].

## 3. Operative technique

All the cases were operated by the same senior surgeon, with the use of a tourniquet and administration of standard prophylactic antibiotherapy consisting of cefazoline.

A semi-curved dorsally skin incision is performed to avoid a medial scar that might be irritated by shoe wear, and care is taken to avoid iatrogenic injury to the dorsal cutaneous nerves.

Soft tissue stripping is limited to the dorsal aspect of the distal metatarsal in order to safeguard the vessels, thereby maintaining adequate perfusion to the distal fragment and minimizing the risk of avascular necrosis.

The capsule of the metatarsophalangeal joint is exposed, and capsulotomy is performed in a V–Y shaped incision. The medial exostosis

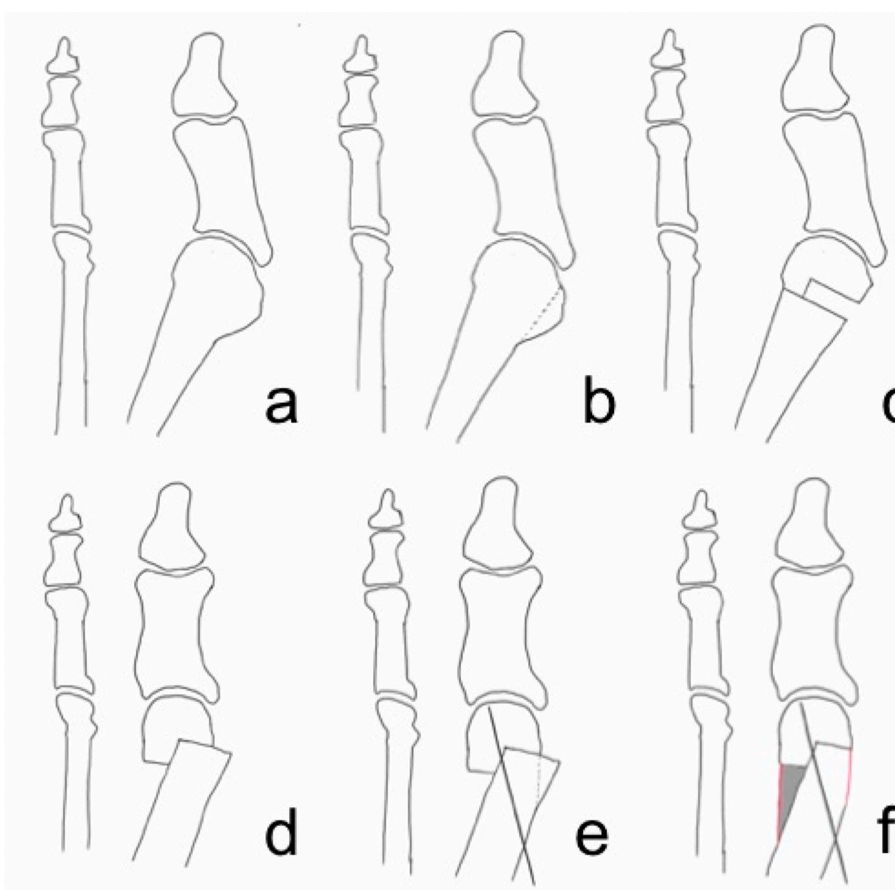


**Fig. 1.** a) Hallux valgus deformity; b) medial exostosis resection c) proximal complete and distal incomplete osteotomies; d) lateral translation of the distal fragment; e) fixation by K-wire; f) bone grafting of the previously excised bunion into the lateral aspect of the cut, with excision and smoothening of the medial protruding edge.

(Fig. 1a) is then excised by the use of an oscillating saw (Fig. 1b).

Two metatarsal cuts are then made; an incomplete distal cut and a complete proximal one (Fig. 1c). The distance between the two cuts is around 2 mm with the aim of avoiding excessive shortening that can lead to the encountered complication of transfer metatarsalgia.

In the sagittal plane the cuts are made slightly oblique by orienting the cut from distal-dorsal to proximal-volar (Fig. 2). This step is important as it allows us to have a desired slight plantarward displacement of the distal fragment to counteract the shortening, as well as the fact that the orientation of this osteotomy prevents unwanted dorsiflexion of the distal fragment and enhances stability of the osteotomy.

As for the mediolateral width of the made step, it should not exceed 25% of the metatarsal width, in order to preserve enough bone contact between the two fragments. After the cuts are made as previously described, lateral translation of the distal fragment is completed (Figs. 1d and 3).

Fixation of the translated fragments is done using one smooth 2.0 mm K-wire placed from the proximal-medial cortex to the distal-lateral subchondral bone of the metatarsal head (Fig. 1e), and the protruding medial edge of the cut is resected to smooth the bony prominences (Fig. 1f).

The cancellous bone is harvested from the previously excised exostosis and bony steps and is used as bone graft placed at the level of the lateral aspect of the cut (Fig. 1f), which promotes for better bone healing by widening the contact surface of the bone.

Intra-operatively the decision is made whether additional lateral soft tissue release is needed or not, this is done by traction on the medial joint capsule proximally. If traction does not reduce the subluxated MTP joint lateral capsular release is done from inside the joint without adding a second lateral incision and further compromising the distal vascularity of the head.

Medial capsulorrhaphy is then done by anchoring and tightening of the capsule to the medially protruding K-wire by two resorbable vicryl 0 sutures, and the correction is adjusted with capsular tension (Fig. 4).

The K-wire is kept exposed for an easy removal after bony union is achieved.

There were no intraoperative complications related to osteotomy or spike fracture, or osteotomy fixation failure.

## 4. Postoperative care

A sterile dressing is applied, and a toe cast is placed to protect the K-wire and stabilize to the osteotomy. The patient is allowed immediate full weight bearing starting with Barouk therapeutic shoes. The sutures are removed at two weeks postoperatively and afterwards the wound is checked every two weeks. At six weeks, an x-ray is done to confirm the bony union at the level of the osteotomy, and the protective toe cast and the K-wire are both removed.

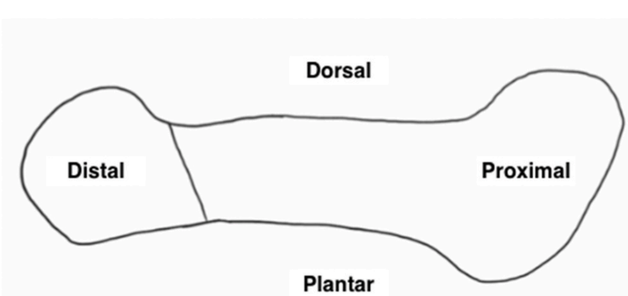


**Fig. 2.** Viewed medially, the cut is made slightly oblique by orienting the cut from distal-dorsal to proximal-volar.

**Fig. 3.** Superiorly observed lateral translation of the distal fragment, with fixation by a single K-wire.

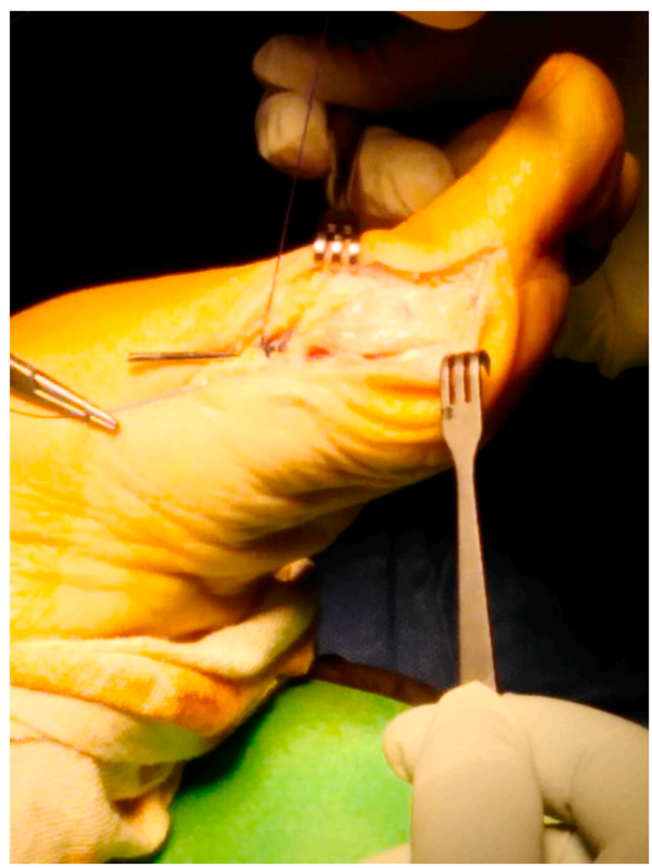

**Fig. 4.** Medial capsulorrhaphy is done by anchoring and tightening of the capsule to the medially protruding K-wire.

## 5. Statistical analysis

The analyses were performed using SPSS 23. A $p < 0.05$ was considered to be statistically significant, with a confidence interval CI 95%.

The data in Table 2 (HVA, IMA, AOFAS score) were tested for normality by Kolmogorov-Smirnov normality test and then analysed using paired-samples *t*-test for variables with normal distribution or Wilcoxon signed rank test for the variables without normality.

In an attempt to assess the impact of the preoperative severity of the deformity on postoperative results, an analysis was done for the presence of a correlation between preoperative IMA and HVA angles and postoperative MT shortening, metatarsalgia, AOFAS scores, as well as AOFAS scores difference. For the metatarsalgia variable, an independent sample T-test was done for the variables with normal distribution and Mann-Witney *U* test for the variables without normal distribution. For the AOFAS score, AOFAS score difference, and metatarsal shortening the linear regression with adjusted $R^2$ was used.

## 6. Results

From the 75 operated patients, one patient had rheumatoid arthritis, two had prior forefoot surgeries and 27 patients were lost to follow-up or had incomplete medical records.

All of our remaining 42 patients were females, of which 25 had bilateral surgeries and 17 underwent unilateral procedures. A total of 67 feet were included in this study, of which 32 were left and 35 were right feet.

The mean age at surgery was 47.8 years (range, 19 to 78). The mean follow-up was 5.2 years (range, 2 to 13). A total of only two patients had postoperative metatarsalgia, which corresponds to 3% (3/67) of all cases (Table 1).

Only one patient had a case of pin tract infection that occurred at four weeks post-operatively, the pin was removed at that time and a short course of antibiotics was administered. Otherwise, no deep infection, hypoesthesia, nonunion, or osteonecrosis of the first metatarsal head were recorded.

Global AOFAS score improved from 45.3 (range, 34 to 64) preoperatively to 88.8 (range, 52 to 100) ($P < 0.01$).

Mean HVA improved from 37.0 pre-operatively to 10.2 post-operatively, mean IMA improved from 12.1 pre-operatively to 5.6 post-operatively ($p < 0.01$).Whereas, the mean metatarsal shortening was 3.0 mm (range, 0–6.0 mm) ($P < 0.01$) (Table 1).

The statistical analysis showed that the comparison of the preoperative to the postoperative values of the HVA, IMA and AOFAS showed a statistically significant difference in all of them (Table 2). The analysis also showed that there is no significant correlation between preoperative HVA and IMA angles with neither postoperative shortening, metatarsalgia, AOFAS scores nor the difference between the preoperative and postoperative AOFAS scores (Table 3).

**Table 1**
Patient demographics.

| Variables | Results |
|---|---|
| **Age** | 47.85 ± 15.85 (19–78) |
| **Follow up** | 5.24 ± 2.40 (2–13) |
| **MT_Shortening** | 3 ± 0.90 (0–6) |
| **Side** | 52.2 (35) |
| **Right** | 47.8 (32) |
| **Left** | |
| **Metatarsalgia** | 3% (2) |
| **Yes** | 97 (65) |
| **No** | |

**Table 2**
Comparison of preoperative to postoperative radiographic measurements and AOFAS scores.

| Measurement | Preoperative | Postoperative | P Value [CI 95%] |
|---|---|---|---|
| **First intermetatarsal angle** | 12.09 ± 3.57 (4,12,20) | 5.56 ± 2.66 (0,5,11) | <0.001[a] [-45.497; −41.608] |
| **Hallux valgus angle** | 37.01 ± 9.25 (17,38,58) | 10.19 ± 4.32 (2,11,19) | <0.001[b] [25.456; 28.186] |
| **AOFAS scores** | 45.28 ± 7.60 (34,44,64) | 88.84 ± 11.18 (52,93,100) | <0.001[b] [6.1612; 6.8836] |

[a] Wilcoxon signed rank test.
[b] Paired-samples *t*-test.

**Table 3**
Correlation between the preoperative hallux valgus severity and surgical outcome.

| | Preoperative IMA | | Preoperative HVA | |
|---|---|---|---|---|
| | **P Value** | **[CI95%]** | **P Value** | [CI95%] |
| **Metatarsalgia Yes No** | 0.396[d] | [18.97; 7.60] | 0.218[c] | [-8.29; 1.92] |
| **AOFAS scores difference** | 0.763 | [-1.51; 1.11] | 0.7 | [-0.60; 0.41] |
| **MT Shortening** | 0.216 | [-0.058; 0.25] | 0.679 | [-0.07; 0.04] |
| **AOFAS scores postoperative** | 0.207 | [-1.25; 0.27] | 0.178 | [-0.49; 0.09] |

[c] Independent sample T-test.
[d] Mann-Witney test, [e]linear regression.

## 7. Discussion

The incidence rate of the hallux valgus deformity varies according to age, with the incidence increasing from 7.8% among the population under the age of 18, to 35.7% in people older than 65 [12].

The initial treatment of this condition is non operative, and non-surgical care should especially be contemplated in people with general hypermobility or ligamentous laxity, neuromuscular disorders, or flat-feet with a pronated first ray because of the high recurrence rate [13].

Distal metatarsal osteotomies should be done when no osteoarthritis of the metatarsophalangeal joint is present. Distal osteotomies were proven to correct the HV deformity in 82%–95% of cases, and previous studies have reported good and excellent results in 91% and 97% of patients [14], as shown in an analytic retrospective study of more than 400 cases [15].

In Mitchell's original osteotomy, the fixation was done by the use of a cerclage wire, with a reported rate of nonunion and loss of correction ranging from 4 to 7%, which is linked to the fixation method which didn't guarantee a firm stabilization [6,16]. Several fixation techniques were later used for better fixation such as crossed pins, Steinman pins, screws, staples, and one K-wire medially buttressing the distal fragment [6,11,16,17].

This procedure is generally indicated in IMAs ≤20 as it is a distal osteotomy, however some surgeons performed it for HVA <40 (moderate hallux valgus) while others also performed it for HVA > 40 with good long-term results (severe hallux valgus) [14,18,19], which is also shown in a long term follow up study on more than 200 cases [17]. We believe that the above described modification is a viable option treatment even for severe hallux valgus deformities with HVA>40.

The encountered complications of this technique have been extensively reported, including loss of correction, transfer metatarsalgia, osteotomy nonunion, and avascular necrosis of the metatarsal head [20].

One of the most common complications of the Mitchell procedure is the shortening of the first metatarsal with the resulting secondary transfer metatarsalgia and plantar callosities, with an incidence rate ranging from 5 to 45% [18,21,22]. However, shortening up to a certain amount is also desired as it relaxes the lateral structures and reduces some of the deforming forces causing this entity [21]. Previous investigations proved that transfer metatarsalgia occurs in shortenings greater than 8–10 mm [19, 23]. In the above described study there is a 3% rate of metatarsalgia, a low occurrence rate that is accounted for by the fact that the mean metatarsal shortening was 3.0 mm (range, 0.0–6.0 mm) with the highest value of shortening being 6.0 mm.

Patients were properly screened pre-operatively, and those with a significantly short first metatarsal (Greek foot) with callosities identified under the heads of the lesser metatarsals were treated by a different surgical technique to avoid further shortening of the first metatarsal as depicted by Heerspink et al. in their comparative study [22].

The low incidence of metatarsalgia in this study is due to several technical reasons. First, the distance between the distal and the proximal cut is around 2 mm, so excess shortening is avoided. Second, the distal fragment is displaced in a plantarward direction to compensate for the shortening and avoiding load transferring to the lateral metatarsals [21]. Third, the orientation of the oblique cut inherently stabilizes the distal fragment against dorsal displacement which could increase the rate of metatarsalgia. Fourth, stable fixation of the osteotomy by the use of a K-wire further prevented loss of correction with the undesired resulting effect of dorsal translation of the distal fragment.

The steps' width didn't exceed 25% of the metatarsal width, in order to preserve enough bone contact between the distal and proximal fragments which would provide the sufficient contact needed to avoid the occurrence of non-union. Stable fixation by a K-wire, as well as bone grafting the lateral aspect of the osteotomy, are essential in achieving bony healing.

Avascular necrosis was prevented by limiting dorsolateral soft tissue dissection in order not to disrupt any vessels, and by doing an intra-articular lateral soft tissue release, when deemed necessary, without adding a second lateral skin incision that might also compromise the distal vascularity.

Compared with the results of previously done studies, in this study the mean HVA correction was of 26.8°, which is similar or higher the other authors' findings (10–26.3)[6,11,16,17,22,24,25,26]. This mean being found on the higher spectrum compared to other authors is due to the fact that patients with HVA >40 were also operated.

Mean IMA correction in other studies varied from 5 to 7.8, this study had a mean of 6.5 which is also similar to the previously reported findings [6,11,16,17,22,24–26].

Concerning the mean metatarsal shortening, the mean was 3.0 mm compared to the previously reported results which ranged from 3.2 to 6.6[2,11,22,24]. This shows that this technique had a satisfactory reported mean of metatarsal shortening, which also partly explains the low occurrence of metatarsalgia in this study.

As for the AOFAS, the mean postoperative score was 88.8 which is similar and even higher than most of the previously reported scores [6,16,17,21].

The modifications to the original technique included:

(1) The distance between the proximal and distal cuts didn't exceed 2–3 mm to avoid excessive shortening
(2) The orientation of the osteotomy was distal-dorsal to proximal-volar which is a protective factor against dorsal displacement of the distal fragment
(3) The width of the step didn't exceed 25% of the whole metatarsal width, which ensured a proper surface of bone contact for bone healing
(4) Fixation was done with a smooth K-wire
(5) Autologous bone grafts were harvested from the resected exostosis and bone cuts, this bone graft was placed on the lateral aspect of the osteotomy to promote union
(6) The medial capsulorrhaphy was tightened around the K-wire, this allowed us to adjust our correction as needed
(7) Lateral release of the metatarso-phalyngeal joint was done through the joint under traction, sparing a lateral incision and decreasing the risk of avascular necrosis.

This modified technique has been previously described in two retrospective outcome studies [27,28], showing promising results with satisfactory long term follow up. In this study on a Middle-Eastern population, the addition of intra-articular lateral soft tissue release, preventing an additional lateral incision, along with the use of autologous bone graft adjacent to the osteotomy stump to improve union, have increased the control over correction as well as improving the rates of union.

There are several weaknesses in the current study. First, it is a retrospective non-randomized study that treated patients with a wide age range. Secondly, there was a significant number of patients that were lost to follow up which inevitably weakened the power of our study. Lastly, only one technique was used and there were no control groups.

On the other hand, this study had several strengths. The fact that all the procedures were done by the same surgeon contributed to the uniformity of the results. This study had a long follow up period stretching up to 13 years, which allowed to monitor the short term as well as the long-term results of this modified technique. The modification to the surgical technique proved to result in very good clinical and radiological outcomes, with a relatively low financial burden compared with the ever-increasing costs of orthopedic implants.

Furthermore, there is absence of a correlation between preoperative HVA and IMA angles with neither postoperative shortening, metatarsalgia, AOFAS scores nor the difference between the preoperative and postoperative AOFAS scores. This suggests that a severe preoperative condition is not associated with a poor outcome for the patient, supporting the use of this modified Mitchell's technique for mild, moderate, and severe cases of hallux valgus disease with an IMA <20.

## 8. conclusion

To conclude, the short- and long-term results of this modified Mitchell's osteotomy with fixation by a k-wire have been reported. It has been statistically proven to be a reliable, reproducible, cost-efficient surgical technique, with low complication rates with satisfactory clinical outcomes.

Emphasis should be done on the importance of proper patient selection, limited soft tissue stripping, and adherence to the proposed surgical steps to avoid unwanted complications.

**Provenance and peer review**

Not commissioned, externally peer reviewed.

## Declarations

- Approval and consent of the ethics committee has been received for the publication of this article.
- Full written consent has been given by the subject patient, no identifiers are included in this article relating to patient identity.
- Availability of data and material: The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.
- Competing interests: The authors declare that they have no competing interests
- Funds: No funds were received in support of this study.

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- Authors contributions:
- RA: writing and editing of this article
- MD: contributed to the writing and editing of this article
- DA: contributed to the writing of this article and the submission process
- JM: contributed to the writing and editing of this article
- JH: contributed to the editing of the figures and of the text
- GA: contributed to the radiological images, and editing of the final text
- CC: contributed with the case, surgical management and editing of the article

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## Ethics approval

St George Hospital University Medical Center.

## Consent to participate

Informed consent was obtained from participant included in the study.

## Consent for publication

The participants have consented to the submission of the case report to the journal.

## Availability of data and material

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

## Declaration of competing interest

The authors declare no conflict of interest regarding the publication of this article.

## Acknowledgements

Not applicable.

## Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.amsu.2021.102259.

## Authors contributions

RA: writing and reviewing the article along with the referencing.
MD: writing and reviewing the article along with the referencing.
DA: writing and editing the article.
JM: writing and editing the article, with editing of the images and radiographs.
JH: Collecting data and editing the article.
GA: Reviewing the article along with the radiological input.
CC: Surgeon who did the surgical procedure, writing and finalizing the article.

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