Acta Clin Croat (Suppl. 3) 2023; 62:60-70
doi: 10.20471/acc.2023.62.s3.8

Original Scientific Paper



# CORRECTION OF HALLUX VALGUS BY SCARF OSTEOTOMY - A CLINICAL AND RADIOGRAPHICAL REVIEW OF 175 CASES

Hrvoje Klobučar, Borna Strahonja and Denis Tršek

Akromion, Special Hospital for Orthopaedic Surgery, Krapinske Toplice, Croatia

SUMMARY – The paper elaborates on scarf osteotomy in the treatment of hallux valgus deformity. The study evaluates 175 isolated scarf osteotomies of the first metatarsal (with/without the Akin procedure) performed by one surgeon. Radiological (intermetatarsal angle-IMA, hallux valgus angle-HVA, distal-metatarsal articular angle-DMAA, proximal-to-distal phalangeal-articular angle-PDPAA, translation of diaphysis and sesamoid position) and clinical (Foot and Ankle Disability Index - FADI and the American Orthopedic Foot and Ankle Score - AOFAS) evaluation was done before and after treatment. The follow-up was from 1 to 10 years. HVA decreased 24˚, from 32˚±8,8(16˚-60˚) to 8˚±7,4(-27˚-32˚), IMA decreased 11˚, from 15˚±3,7(16˚-31˚) to 4˚±2,4(0˚-13˚), DMAA for 12˚-from 17˚ to 5˚, PDPAA for 5˚-from 5˚ to 0˚ and sesamoid position from 5(2-7) to 1(1-7). The first metatarsal translation was 58%±14,5(17%-94%). FADI enlarged from 65±18.2(26-99) to 95±9,7(45-100) and AOFAS from 76±9,to 6(47-98) 96±6,9(72-100). All diferences were significant (p<0,05). Recurrence was 4,6%, iatrogenic hallux varus 6,3%, symptomatic screw 9%, transfer metatarsalgia 2,3%, troughing 2,9% superficial wound infection 1,1%, and postoperative hypesthesia 1,1%. Scarf osteotomy is a reliable and safe procedure for the correction of moderate to severe hallux valgus deformities. A relatively long learning curve is a burden with solvable complications.

Keywords: *scarf osteotomy, hallux valgus, first metatarsal osteotomy, scarf learning curve*

## Introduction

More than 130 different procedures are present in surgical armament for operative corrections of hallux valgus deformity. That asserts that neither procedure is solely efficient, but also it points out that this deformity is multifactorial in origin and development 1[-2]. The surgeon has to take into consideration the hyperlaxity and thus hypermobility of the first ray, the structural deformity of the distal first metatarsal (as in juvenile hallux valgus with metatarsus adductus and high distal metatarsal articular angle - DMAA) or osteoarthritic conditions[3]. Scarf osteotomy is one of the diaphyseal osteotomies that provides a wide range of correction possibilities. The word scarf is a carpentry term that presents a way of tailoring and connecting two fragments of wood as a strong and stable construct. This method was inaugurated by Burutaran in 1976., and popularised and further developed by Weil and Barouk[4,5]. The main issue of this procedure is the „Z“ -shaped incision of the first metatarsal bone with the transversal long or short incision positioned parallel to the floor (Figure 1a).[6] The products are two bone fragments with the distal (inferior) one translated laterally. The width of the first metatarsal bone and the length of the longitudinal cut allows generous correction. The orientation of the incisions influences plantarisa-

Correspondence to: *Hrvoje Klobučar*
Ljudevita Gaja 2, 49217 Krapinske Toplice
hrvoje.klobucar@akromion.hr

tion (plantary directed cuts), shortening (proximally directed cuts), or rotation/derotation (turning distal fragment medially or laterally with different amounts of translation in the proximal and distal parts of the osteotomy) (Figure 1b-e)[7,8]. Adequate tailoring and interpressing bone fragments allow the surgeon to achieve maximum primary stability of the osteotomy even without the need for screw fixation (Figure 2)[9,10,11]. Scarf osteotomy is indicated for medium and large deformities of the hallux valgus, with an expected reduction of the intermetatarsal angle (IMA) and the hallux valgus angle (HVA). It is usually followed by adjuvant Akin osteotomy for the correction of hallux interphalangeal valgus. Scarf osteotomy of the first metatarsal as a method with a long learning curve is burdened with complications that appear in 30% to 78% (revalgisation, iatrogenic hallux varus, implant failure, neurological complications, troughing and, metatarsalgia, infections)[12,13,14].

## Methods

During the period of ten years, a single surgeon treated 343 hallux valgus deformities with diaphyseal scarf osteotomies of the first metatarsal with or without adjuvant procedures on the hindfoot or forefoot. Solely the first ray deformity treated with metatarsal scarf osteotomy with or without Akin procedure was performed in 175 patients. There were two types of scarf osteotomies performed; the standard scarf (a long diaphyseal longitudinal incision and fixation with two screws) and the short scarf (a short longitudinal incision and fixation with one screw). All Akin osteotomies were fixed with one screw or a Barouk clamp. In 174 patients, headless compression titanium screws were used. During these ten years, we used FRS (Foot Reconstruction Screw 3,0mm, Zimmer Biomet, Warsaw, USA), ITS screw 2,5mm (ITS, Leoben, Austria), and Compression FT screw 2,5mm (Arthrex, Naples, USA). In one patient, fixation material was not used – Maestro modification of distal and proximal impaction was done. Before and at least one year after the procedure, subjective and objective foot status was evaluated with the Foot and Ankle Disability Index (FADI) and the American Orthopaedic Foot and Ankle Score (AOFAS)[15]. Radiologic parameters were evaluated on the preoperative and on the last postoperative visit (at least one year after surgery). Evaluation on a standard weight-bearing foot X-ray was done (hallux valgus angle-HVA, intermetatarsal angle-IMA, distal metatarsal articulation angle – DMAA, proximal-to-distal

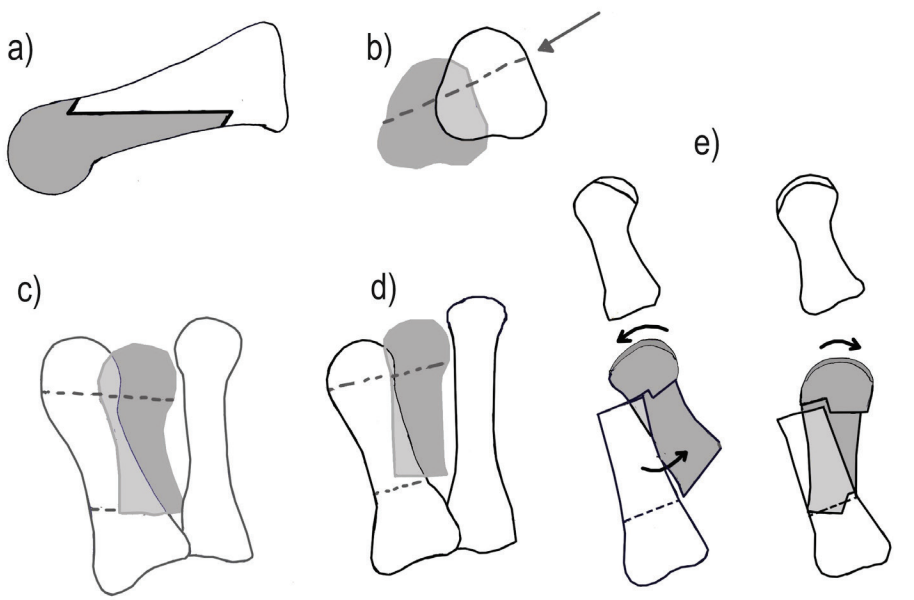



*Figure 1. a) „Z" shaped osteotomy of the first metatarsal, b) plantarisation of the first metatarsal is achieved by directing the longitudinal incision plantary and laterally, c) shortening of the first metatarsal is achieved with proximally directed vertical incisions, d) elongation of the first metatarsal is achieved with distally directed vertical cuts, 3) rotation of the distal fragment in transversal plane can correct the distal metatarsal articulation angle (DMAA).*

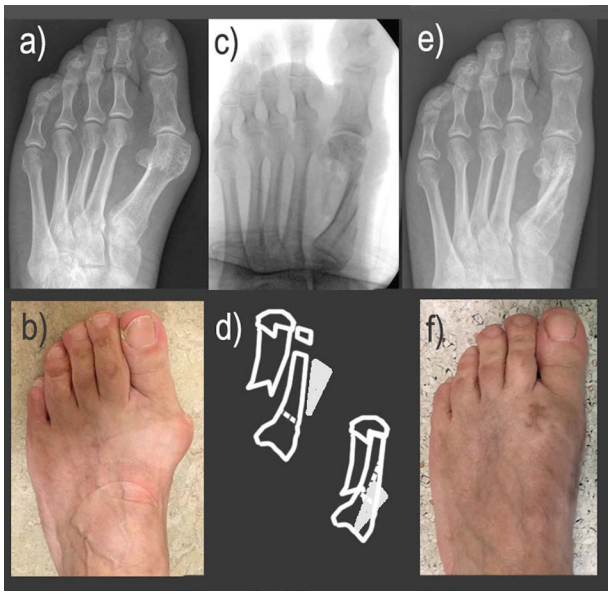



*Figure 2. Scarf osteotomy without screw fixation. a) preoperative X-ray; b) preoperative photo of the deformed foot; c) intraoperative fragment positioning; d) scheme of fragment resection, tailoring, and interpressing; e) postoperative X-ray; f) postoperative photo of the operated foot.*

phalangeal articular angle – PDPAA, and the amount of the largest diaphysis translation). The sesamoid position was evaluated radiologically and classified according to the Hardy and Clampton scale, evaluating the position of the medial sesamoid on a scale from 1-7[16]. Distribution was tested employing the Goodness of Fit Kolmogorov Smirnov test and a student t-test or the Man-Whitney U test was performed for testing paired samples.

The same surgeon operated on all patients. Surgery was performed under regional anaesthesia, a tourniquet was applied above the ankle. The lateral release was performed whenever the first metatarsal joint incongruence/subluxation was present. Then, the open release of metatarsosesamoid suspensory ligament and dissection of the adductor hallucis tendon were done. A medial approach on the first metatarsal and first proximal phalanx was used with a longitudinal incision of the capsule. Short or long „Z" osteotomy of metatarsal diaphysis parallel with the sole of the foot in the standard way according to Barouk or with distal wedging and impaction according to Maestro and lateral translation of distal fragment were performed (Figure 2)[5,9]. Additionally, the distal metatarsal fragment was rotated medially to correct DMAA if it was enlarged. The direction of the incisions can however influence and determine the length of the first metatarsal (Figure 1). In all but one patient, fixation was done with one or two headless compression titanium alloy screws. The resected medial distal part of the proximal fragment was impacted in the proximal plantar segment of the osteotomy site for additional stabilisation of the fragments. After the load test, it was decided whether to perform the Akin procedure or not – depending on the hallux orientation and if residual valgus deformity persists in the interphalangeal joint. Medial oblique closing wedge osteotomy directed from medial distal to proximal lateral on the base of the proximal phalanx is fixed with one headless compression screw or with a Barouk fixation clamp. After surgery, Molndal dressing (Aquacel+Granuflex) and a soft bandage was put on the foot and kept for six days. The patient was allowed to walk in protective shoes with the load on the heel of the operated leg starting from the second postoperative day. The sutures were removed after 14 days and the protective shoe after 4-6 weeks - depending on the amount of correction (bone fragment translation), bone quality, smoking status, and body weight. X-ray control was performed immediately after surgery, after 6 weeks, 3 months, and one year after surgery. The patients were monitored for 1-10 years.

## Results

Among the 175 first metatarsal scarf osteotomies, there were 165 women and 10 men, the average age was 47(15-83) years, 86 left and 89 right feet. Both feet were operated in one surgical procedure on 40 patients (Figure 3). An additional Akin (medial closing wedge) osteotomy of the proximal phalanx was performed in 139 patients (79%). A short scarf fixed with one screw was done in 14 patients and a standard, long scarf fixed with 2 screws was performed in 161 patients. In 16 feet we have done the first metatarsal scarf osteotomy as a revision procedure - after different types of hallux valgus corrections were tried previously (bunionectomy, chevron osteotomy, or previous scarf). Three patients had rheumatoid arthritis. Preoperative $FADI_1$ was 65±18.2(26-99) and postoperative $FADI_2$ 95±9,7(45-100). Preoperative $AOFAS_1$ was 76±9,6(47-98) and postoperative $AOFAS_2$ was 96±6,9(72-100). Hallux valgus angle diminished from $HVA_1$ 32°±8,8(16°-60°) preoperatively to $HVA_2$

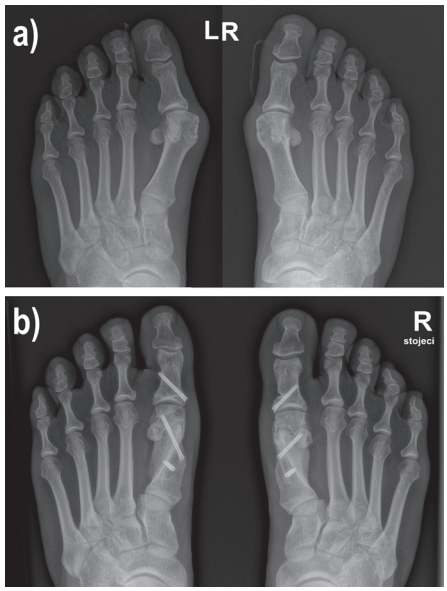



*Figure 3. Bilateral scarf and Akin osteotomy: a) X-rays of both feet before surgery, b) X-rays one year after surgery.*

postoperatively 8°±7,4(-27°-32°). Intermetatarsal angle IMA also decreased from $IMA_1$ preoperatively 15°±3,7(16°-31°) to $IMA_2$ postoperatively 4°±2,4(0°-13°). A subluxated first metatarsophalangeal joint was found in 129 feet (74%) and an osteoarthritic joint in 48 feet (27%). Distal metatarsal articulation angle (DMAA) was reduced from $DMAA_1$ 17°±10,4(-9°-57°) before to $DMAA_2$ 5°±10,4(-17°-37°) after surgery. Proximal-to-distal phalangeal articular angle (PDPAA) corrected with Akin osteotomy was from $PDPAA_1$ 7°±4,4(0°-20°) before surgery to $PDPAA_2$ -1°±4,7(-14°-9°) after the operation. The largest translation amount of diaphysis width was 58%±14,5(17%-94%). All these differences were statistically significant (p<0,05). To summarize the amount of median surgical correction of radiologic parameters; HVA angle 24°(from 32° preoperative to 8° postoperative), IMA angle 11° (from 15° preoperative to 4° postoperative), DMAA 12° (from 17° to 5°) and PDPAA 5° (from 5° to 0°). When analysing the difference in correction potential of short and long scarfs, in this study 161 long scarfs followed the overall corrective capacity of the whole cohort – reduction of IMA for 11° , HVA for 24°, and DMAA for 9°. Fourteen short scarfs in this study presented lower corrective potential – reduction of IMA for 7,5° , HVA for 16° and DMAA for 7° mainly because of lesser initial deformity (short scarf: $IMA_1$ 11,5; $HVA_1$ 23; $DMAA_1$ 13,5). A ten-year learning curve with a median of correction for each year is presented in Graph 1. The medial sesamoid position was evaluated according to Hardy and Clapham and it decreased from the preoperative median 5(2-7) to the postoperative median 1(1-7) (Graph 2). Among 175 operated, 66 patients had some type of complaint after surgery (38%). In 25 (14%) patients, we removed the screws (Figure 4), but 9 of them did not have pain – they just wanted to remove the metal from the body – so screw discomfort was found in 16 patients (9%). Four patients (2,3%) have metatarsalgia and 4 patients (2,3%) had malrotation due to postoperative fracture and hypertophic callus. A reduced first metatarsophalangeal ROM (less than 40°) was found in four patients (2,3%). Troughing was found in 5 patients (2,9%) and superficial wound infection treated with antibiotics in 2 patients (1,1%). In one patient (0,5%) delayed wound healing caused wound revision. Revalgisation happened in 8 patients (4,6%) but only two patients decided to undergo a reoperation procedure or a recorrection with scarf osteotomy (Figure 5). Postoperative varus has been radiologically found in 11 patients (6,3%), but only 2 patients (1,1%) had shoe discomfort and pain and needed revision surgery. Two patients (1,1%) had postoperative hypesthesia in the plantar metatarsal region after a regional nerve block. This discomfort lasted for a period longer than 4 months after surgery. Among the whole cohort, a subgroup of short scarf osteotomies presented only two implant removals, one superficial wound infection, and one joint contracture. Graphs 3 and 4 present the learning curve – distribution of surgeries and complications of scarf osteotomies for the single surgeon through a 10-year period.

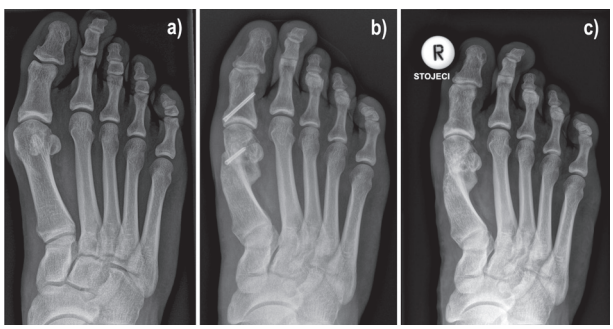



*Figure 4. Short scarf osteotomy. a) X-ray before surgery, b) X-ray after scarf and Akin osteotomy, c) X-ray after screw removal.*

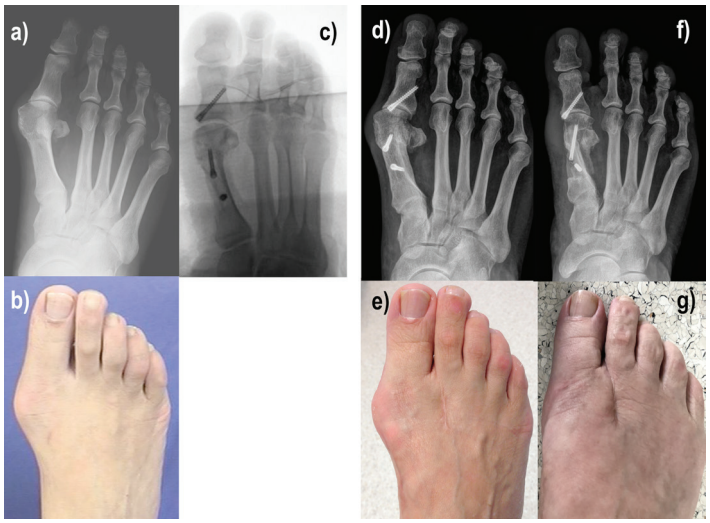
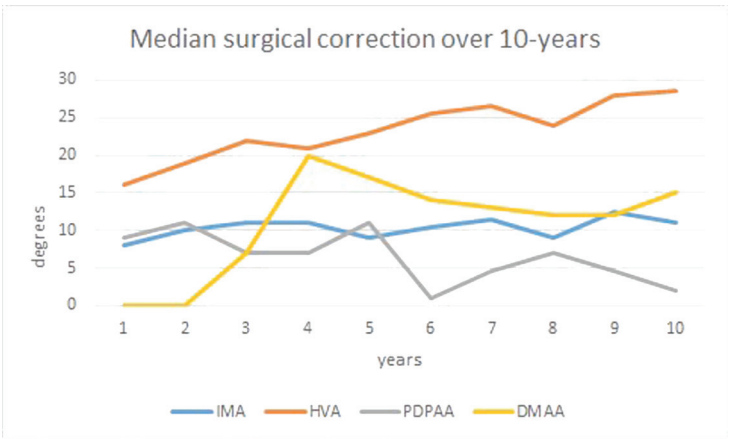
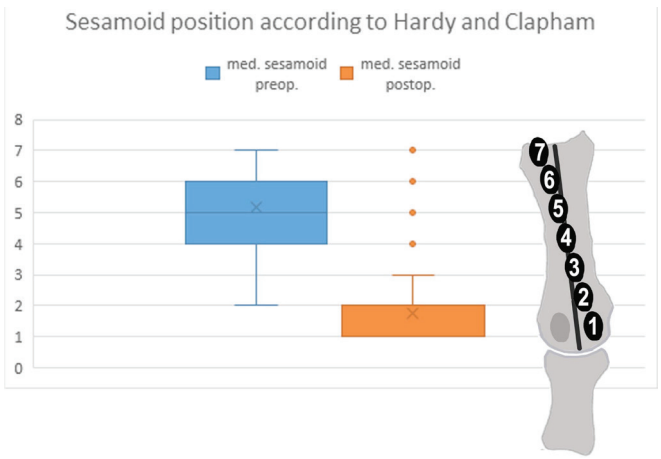


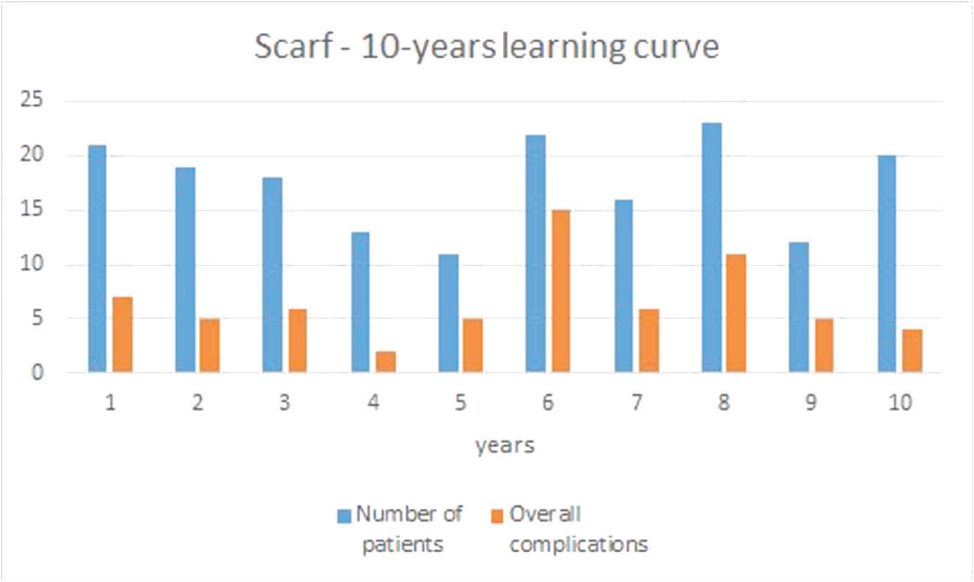

*Figure 5. Recurrence of hallux valgus after scarf osteotomy. a) X-ray before surgery, b) foot photo before surgery, c) X-ray after long scarf and Akin, d) revalgisation – X-ray nine years after surgery, e) the foot nine years after surgery, f) recorrection with scarf osteotomy – X-ray 6 months after second surgery, g) foot photo six months after revision surgery.*



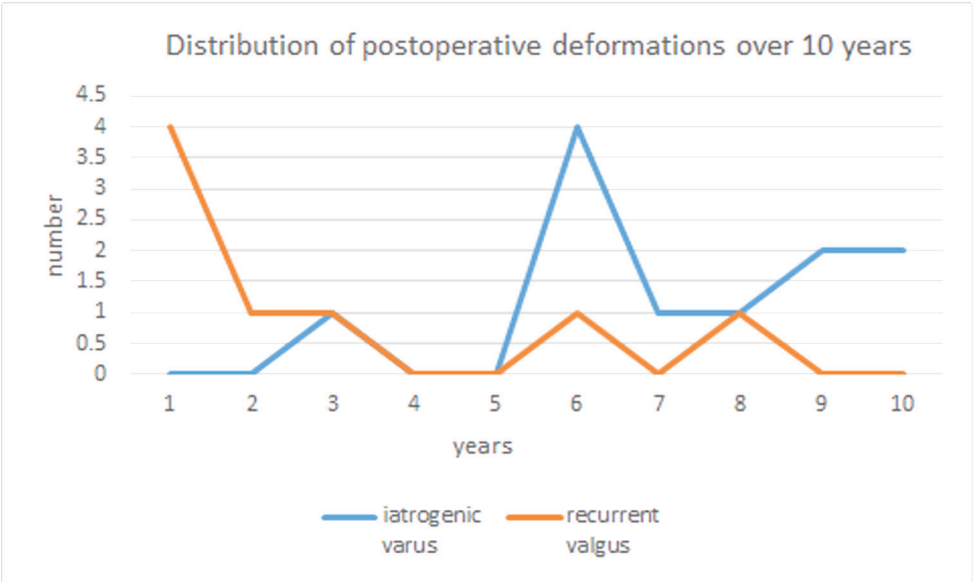

*Graph 1. The median of radiological parameters corrected in patients operated on each year over a 10-year period.*




*Graph 2. Median position of the medial sesamoid before and after the surgery according to Hardy and Clapham classification.*




*Graph 3. Distribution of the number of performed scarf osteotomies and complications over a 10-year period.*




*Graph 4. Distribution of the number of postoperative deformities – revalgisation and varisation after scarf osteotomies over a 10-year period.*

## Discussion

Scarf osteotomy of the first metatarsal is a powerful method for the correction of hallux valgus deformity. It is usable in various degrees of deformities; those with large IMT angle, negative metatarsal index, positive metatarsal index, large DMAA, small DMAA, subluxated or osteoarthritic first metatarsophalangeal joint, in adolescents as well as in osteopathic and rheumatoid patients[5,17,18,19]. Barouk emphasised that first-ray correction is rarely indicated without some other procedure in the forefoot[5]. As it is presented, scarf can correct moderate to severe HV deformity with a preoperative seriously irregular Maestro metatarsal curve and that is why we may need additional ray treatment. This study includes only 175 isolated first-ray scarf osteotomies (51%) abstracted among 343 scarf osteotomies that are combined with procedures on other

parts of the foot. Our median correction of HVA is 24° (from 32° to 8°) and IMA 11° (from 15° to 4°). This amount of correction is generous and cannot be found routinely in other studies[11,20,21,22,23]. Deenik et al. in a study on 108 feet found similar correction potential with a scarf and with a chevron (HVA from 30° to 18° and IMA from 13° to 10°)[24]. Garirido et al on 30 patients achieved maximal average correction of HVA of 17.4° and IMA of 5.8° and a similar DMAA correction of 9° as in our study (12°)[17]. Also, the same study reports a high frequency of complex regional pain syndrome which we did not see in our series. In our study, 40 patients' operations were performed bilaterally. (Figure 3). There are different techniques and modifications of scarf osteotomies. Short scarf osteotomy resembles long chevron osteotomy but is more stable due to the impaction of the plantar „Z" arm of the osteotomy. It also decreases postoperative scarring, operative time, and the number of used screws, allowing this type of osteotomy to be minimally invasive (MIS)[6]. Long scarf osteotomy gives greater bone contact between fragments and has a greater potential for reducing IMA. Short scarf osteotomy allows greater rotational potential (for correction of DMAA)[8]. Short scarf osteotomy is very usable in mild deformities with high DMMA but large corrections diminish bone contact between fragments, enlarge the load on screws and destabilise the osteotomy site. The surgeon in this study performed only 14 short scarfs that were mainly used for mild to moderate HV deformities (Figure 4).

Large DMAA after surgery is one of the main reasons for the recurrence of deformities[14,26,27]. Scarf osteotomy is a method that corrects DMAA better than any other surgical procedure[5]. Because of its larger rotational potential, short scarf osteotomy is preferable over long scarf osteotomy for larger DMAA corrections[8]. In this study, the author achieved a postoperative median DMAA of 5° which is within the normal range (<8°). The author got even better results with long scarf osteotomies than with short scarfs (median DMMA correction of 12° versus 7°). In the whole cohort, we did not have nonunions, although our translations of bone fragments were large. Our average and median bone fragment lateral translation is 58% with a maximal translation of 94% of diaphyseal width. Encouraged by the good healing potential in scarf osteotomies, the surgeon exceeded the translation of bone fragments for the full width of diaphysis in the proximal part of osteotomies in rotational scarfs. Thus, the surgeon had enough bone structure to add a second, longer screw in the proximal part that optimally stabilises the osteotomy.

Akin osteotomy is advised as an adjuvant procedure to scarf osteotomy if hallux valgus interphalangeus persists or when the proximal-to-distal phalangeal articular angle (PDPAA) is greater than 8°[28]. Due to the rotation of the proximal phalanx (pronation) preoperative measuring of PDPAA is not precise, thus the decision to perform this osteotomy has to be made after the scarf correction as a fine-tuning of the hallux valgus position. Shibuya and coauthors raised a question about the efficacy of this osteotomy due to the relatively high HVA and laterally deviated sesamoids[29]. Our results do not follow these observations – maybe because we strictly follow the indication for Akin – the presence of interphalangeal valgus. Akin osteotomies have been done in 79% of operated feet in this cohort. It should never be used as a corrector of inadequate scarf translation, inappropriate sesamoid position, or HVA and IMA correction[27].

Recurrence or revalgisation is one of the major concerns among postoperative complications. A hallux valgus angle higher than 15° or 20° is usually defined as a threshold for recurrence.[12] Our median and average HVA after surgery was 8°. Studies with a follow-up of less than two years present a recurrence rate of up to 10%, but longer follow-up yields higher rates of recurrence – even up to 30%[12]. Trnka et al. in their study reveal that most of the recurrences developed between 1,5-2,8 years after surgery[14]. They differentiate between symptomatic and asymptomatic recurrence among patients with revalgisation after scarf osteotomy. That is very important regarding making the decision for revision surgery[14]. Properly performed and addressed scarf osteotomy balances soft tissues and brings bones and joints in the optimal position, thus reducing the complication of revalgisation, even in patients with first-ray instability[30]. The reasons for recurrence are under-correction, long first metatarsal, large DMAA, hyperpronated first metatarsal, hypermobile first ray or inadequate sesamoid position high body mass, disrupted Meary line, systemic diseases, neuromuscular disorders, surgical technique, surgeon´s expertise[1,2,12,18]. Trnka et al. in a study on 104 patients treated with first metatarsal scarf osteotomy with strict follow-up of 10 years presented a 30% recurrence rate. Predictive values for recurrence were a preoperative IMA>18° and HVA>30°[14]. Our recurrence rate was

4,6% (8 patients) with 50% of these in the first year of the surgeon's experience with scarf osteotomies (Graph 2, Figure 5). Undercorrection, inadequate shortening, and neglected sesamoid position are the main multifactorial reasons for these recurrences. Only two patients developed symptoms that urged revision surgery – another scarf osteotomy. Other patients coped with revalgisation without surgery, suffered minor symptoms or were completely asymptomatic.

We evaluated patient satisfaction preoperatively and postoperatively on the last visit. FADI enlarged by 30 (from 65 to 95) and AOFAS by 30 (from 76 to 96). Similar results can be found in the literature. One of the highest score enlargements presented in the study of Crevoisier et al. where the mean AOFAS score raised significantly from 43 points preoperatively to 82 points after surgery[19]. Trnka et al. found that AOFAS of 85 and 95 respectively depends on if recurrence did or did not occur[14]. Adam et al presented an average preoperative AOFAS score of 61.5 improved to 90.3, indicating a very good functional restoration of the forefoot[21]. But in the studies that present a lesser degree of correction in HV surgery, the scores are lower. Ugur et al. presented preoperative AOFAS improved from 58 to 78, but with concomitant HVA correction of 15° and IMA of 6° without change in DMAA[18]. In the same study, iatrogenic hallux varus developed in two feet (5 %), and one needed surgery[18]. Iatrogenic hallux varus post scarf osteotomy has an incidence from 1% to 15% (mostly 4%-5%) in different studies[31,32]. The main reasons for developing iatrogenic hallux varus are overcorrection (IMA<0°, HVA<0° or combination), dissection of lateral collateral metatarsophalangeal ligament, detachment of the lateral head of flexor hallucis brevis, over-tightening of the medial capsule and medially subluxed medial sesamoid, too generous Akin correction or combination of these[32]. Eleven of our patients (6,3%) satisfied the criteria for iatrogenic hallux varus, but only two needed surgery. Reasons for varus were the large correction of IMA, DMAA, and PDPAA in combination with lateral collateral ligament (LCL) injury and medial capsule overtightening. In both patients, the reverse scarf was done with LCL reconstruction.

Troughing is one of the major complications that can produce unpleasant postoperative transfer metatarsalgia. It happens when bone fragments enter each other like roof tiles in a gutter[33]. Inevitably, that leads to elevation of the first metatarsal and reduction in ROM of the first metatarsophalangeal. The second metatarsal is overloaded in the second and third rocker[33]. There are different ways to avoid this problem; crossing the cortices of fragments during their rotation or technical supports that keep the fragments in the desired place until screw placement[13,34,35,36]. We found 5 patients (2,9%) with troughing (on lateral X-rays) and overall 4 patients (2,6%) with postoperative metatarsalgia. In two patients, further forefoot reconstruction with Weil osteotomies was performed and in one patient, a painful medial sesamoid was removed. Ugur et al. found transfer metatarsalgia in two feet (5 %) treated conservatively[18]. Trnka et al. found only in 3 out of 108 patients (3%) with this complication and they were treated conservatively[14]. Because of its versatility, scarf osteotomy is an excellent method as a revision procedure. Bock et al. confirmed that a revision scarf reduces pain, improves AOFAS, and corrects HVA, IMA, DMAA, and sesamoid position, but these radiologic parameters have a tendency to increase over a 6-week period[37]. In this series the author performed 16 revisions with scarf procedures, 3 of them were previously operated by the same surgeon and also with scarf osteotomy; one was a case of malrotation and two were revalgisations. In a group of 16 revisions, three patients (25%) had prominent screws that were removed, and there were no other complications.

Accurately following the main principles of the technique by performing the proximal plantar approach, surgeons can preserve the main vascular structures and blood supply for the metatarsal head and the plantar bone fragment of the first metatarsal[5]. Thus osteonecrosis of the first metatarsal head is a rare complication[14,23]. In our study, we did not find avascular necrosis of the humeral head. This is also confirmed by other authors[5,12].

Scarf osteotomy as a joint preserving procedure in correcting hallux valgus in rheumatoid patients was established by Barouk and further developed by other authors[5,14]. In our cohort, we have had 3 RA patients. One patient had recurrence, but without symptoms and with no need for further surgery.

Implant removal was necessary for 3% of patients in a study by Jones et al[38]. Garrido et al. presented implant removal in 11% of patients[17]. Trnka et al removed implants in 11% of patients in their study[14]. In our study, we had 16 patients (9%) with unpleasant and symptomatic implants that needed to be removed, although we used only headless screws. Nine patients asked for implant

removal, although there was no pain or discomfort. In one patient, we performed screwless fixation and there were no complications in this patient.

Seng et al. evaluated the learning curve in the scarf technique regarding the evaluation of the sesamoid position. They found a strong connection between the optimisation of the sesamoid position and the reduced risk of recurrence[39]. In our study, we also got a nice correction of the sesamoid position. The medial sesamoid was preoperatively dislocated laterally beyond the midline of the first metatarsal (median position 5 according to Hardy and Clapham) and after surgery, it was eutopically positioned (median position 1). This can also explain the relatively low rate of recurrence in our cohort.

## Conclusion

Scarf osteotomy of the first metatarsal is a very demanding surgical technique in the correction of hallux valgus deformity. It is a very powerful tool in the hands of a foot surgeon who has the opportunity to eventually correct almost any type of hallux valgus deformity only with considerate planning and performing the scarf osteotomy. However, encumbered with a lot of technical traps, this method is slow learning. It must be simply used by an experienced surgeon who has to follow the basic principles of hallux valgus treatment. The surgeon has to address all predictive factors and prognostic elements for recurrence, taking care not to overcorrect the deformity.

## Disclosure of conflict of interest

Hrvoje Klobučar, MD, PhD – Arthrex Consultant
Borna Strahonja, MD – nothing to disclose
Denis Tršek, MD, PhD – Johnson & Johnson Consultant

Authors did not take any funds or grants in planning, designing, performing or publishing the study.

## References

1. Castioni D, Fanelli D, Gasparini G, Ianno B, Galasso O. Scarf osteotomy for the treatment of moderate to severe hallux valgus: Analysis of predictors for midterm outcomes and recurrence. Foot and Ankle Surgery. 2019: 1-6. doi: 10.1016/j.fas.2019.05.013
2. Perera A, Mason L, Stephens M. The Pathogenesis of Hallux Valgus, J Bone Joint Surg Am. 2011; 93:1650-61. doi: 10.2106/JBJS.H.01630.
3. Smyth N, Alyer A, Mayerson M. Introduction: Why Are There So Many Different Surgeries so Many Different Surgeries for Hallux Valgus? Foot Ankle Clin N Am. 2018 Jun;23(2):171-182. doi: 10.1016/j.fcl.2018.01.001.
4. Burutaran J. Hallux valgus y cortedad anatomica del primer metatarsano (correction quirurgica). Acual Med Chir Pied 1976 XII:261-66
5. Barouk LS. Scarf osteotomy for hallux valgus correction. Local anatomy, surgical technique, and combination with other forefoot procedures. Foot and Ankle Clinics of North America. 2000 Sep;5(3):525-58.
6. Boksh K, Qasim S, Khan K, Tomlinson C. A Comparative Study of Mini-Scarf Versus Standard Scarf Osteotomy for Hallux Valgus Correction. The Journal of Foot & Ankle Surgery. 2018 Sep-Oct;57(5):948-951. doi: 10.1053/j.jfas.2018.03.039. Epub 2018 Jul 9.
7. Swanton E, Mason L, Molloy A. How Do I Use the Scarf Osteotomy to Rotate the Metatarsal and Correct the Deformity in Three Dimensions. Foot Ankle Clin N Am. 2018 Jun;23(2):239-246. doi: 10.1016/j.fcl.2018.01.008.
8. O'Briain D, Flavin R, Kearns S. Use of a Geometric Formula to Improve the RadioGraphic Correction Achieved by the Scarf Osteotomy. Foot & Ankle International. 2012 Aug;33(8):647-54. doi: 10.3113/FAI.2012.0647.
9. Leemrijse T, Maestro M, Tribak K, Gombault V, Devos Bevernage B, Deleu P. Scarf osteotomy without internal fixation to correct hallux valgus. Orthop Traumatol Surg Res. 2012 Dec;98(8):921-7. doi: 10.1016/j.otsr.2012.07.008.
10. Liszka H, Gadek A. Results of Scarf Osteotomy Without Implant Fixation in the Treatment of Hallux Valgus. Foot & Ankle International. 2018 Nov;39(11):1320-1327. doi: 10.1177/1071100718786498. Epub 2018 Jul 13.
11. Van Doninck D, Verschueren T, Matricali D, Van Opstal N, Scheys L, Vandeputte G. Screwless Scarf osteotomy for hallux valgus: evaluation of radiologic correction. Foot and Ankle Surgery. 2017 Dec;23(4):255-260. doi: 10.1016/j.fas.2016.07.002. Epub 2016 Jul 18.
12. Clarke T, Platt SR. Treatment of hallux valgus by Scarf osteotomy - rate and reasons for recurrence and rates of avascular necrosis: A systematic review. Foot and Ankle Surgery. 2021 Aug;27(6):622-628. doi: 10.1016/j.fas.2020.08.009.
13. Eeasly M, Trnka HJ. Current Concepts Review: Hallux Valgus Part II: Operative Treatment. Foot & Ankle International. 2007 Jun;28(6):748-58. doi: 10.3113/FAI.2007.0748.
14. Bock P, Kluger R, Kristen K, Mittelboeck M, Schuh R, Trnka HJ. The Scarf Osteotomy with Minimally Invasive Lateral Release for Treatment of Hallux Valgus Deformity: Intermediate and Long-Term Results. J Bone Joint Surg. 2015 Aug 5;97(15):1238-45. doi: 10.2106/JBJS.N.00971.
15. Hale S, Hertel J. Reliability and Sensitivity of the Foot and Ankle Disability Index in Subjects With Chronic Ankle Instability. Journal of Athletic Training. 2005 Jan-Mar; 40(1): 35–40.
16. Hardy R, Clapham J. Observations on Hallux Valgus. Based on a Controlled Series. J Bone Joint Surg. 1951; 33B(3):376-391.
17. Garrido I, Bosch Navarro M, Gonzales M, Bastida Paz G, Llabres A. Scarf and Akin osteotomies for moderate and se-

vere hallux valgus. Clinical and radioGraphic results. Foot and Ankle Surgery. 2008, 14 (4): 194-203.

18. Ugur S, Akman B, Tanriover A, Kaspar C, Guven M, Ozler T. The results of scarf osteotomy combined with distal soft tissue procedure are mostly satisfactory in surgical management of moderate to severe hallux valgus. Foot and Ankle Surgery. 2018 Oct;24(5):448-452. doi: 10.1016/j.fas.2017.05.001. Epub 2017 May 29.
19. Crevoisier X, Mouhsine E, Ortolano V, Udin B, Dutoil M. The Scarf Osteotomy for the Treatment of Hallux Valgus Deformity: A Review of 84 Cases. Foot and Ankle International. 2001 Dec;22(12):970-6. doi: 10.1177/107110070102201208.
20. Deenik A. Mameren H, de Visser H, de Waal Malefijt M, Frits D. Equivalent Correction in Scarf and Chevron Osteotomy in Moderate and Severe Hallux Valgus: A Randomized Controlled Trial. Foot and Ankle International. 2008 Dec;29(12):1209-15. doi: 10.3113/FAI.2008.1209.
21. Adam S, Choung S, Gu Y, O´Malley M. Outcomes after scarf osteotomy for treatment of adult hallux valgus deformity. Clin Orthop Relat Res. 2011 Mar;469(3):854-9. doi: 10.1007/s11999-010-1510-6. Epub 2010 Aug 13.
22. Smith S, Landorf K, Butterworth P, Menz H. Scarf versus Chevron Osteotomy for the Correction of 1–2 Intermetatarsal Angle in Hallux Valgus: A Systematic Review and Meta-analysis. The Journal of Foot & Ankle Surgery. 2012 Jul-Aug;51(4):437-44. doi: 10.1053/j.jfas.2012.02.016. Epub 2012 Apr 8.
23. Jaeger M, Schmidt M, Wild A, Bittersohl B, Courtois S, Schmidt T et al. Z-osteotomy in hallux valgus: clinical and radiological outcome after Scarf osteotomy. Orthopedic Reviews. 2009 Jun 30;1(1):e4. doi: 10.4081/or.2009.e4.
24. Deenik A, Pilot P, Brandt S, van Mameren H, Deenik R. Scarf versus Chevron Osteotomy in Hallux Valgus: A Randomized Controlled Trial in 96 Patients. Foot Ankle Int. 2007 May;28(5):537-41. doi: 10.3113/FAI.2007.0537.
25. Boichenko A, Solomin L. Efficacy of Bilateral Simultaneous Hallux Valgus Correction Compared to Unilateral. Foot & Ankle International. 2015 Nov;36(11):1339-43. doi: 10.1177/1071100715589174. Epub 2015 Jun 24.
26. George H, Casaletto J, Unnikrishnan PN, Shivratri D, James LA, Bass A et al. Outcome of the scarf osteotomy in adolescent hallux valgus. J Child Orthop. 2009 Jun;3(3):185-90. doi: 10.1007/s11832-009-0177-6. Epub 2009 May 7.
27. Scranton PJ, McDermott J. Prognostic factors in bunion surgery. Foot Ankle Int. 1995 Nov;16(11):698-704. doi: 10.1177/107110079501601105.
28. Kaufmann G, Hofer P, Braito M, Bale R, Putzer D, Dammerer D. Effect of Akin Osteotomy on Hallux Valgus Correction After Scarf Osteotomy With Hallux Valgus Interphalangeus. Foot & Ankle International. 2019 Oct;40(10):1182-1188. doi: 10.1177/1071100719855043. Epub 2019 Jun 14.
29. Shibuya N, Thorud J, Plemmons B. Evaluation of Hallux Valgus Correction With Versus Without Akin Proximal Phalanx Osteotomy. The Journal of Foot & Ankle Surgery. 2016 Sep-Oct;55(5):910-4. doi: 10.1053/j.jfas.2016.03.016. Epub 2016 Jun 8
30. Faroug R, Bagshaw O, Conway L, Ballester JS. Increased recurrence in Scarf osteotomy for mild & moderate hallux valgus with Meary's line disruption. Foot Ankle Surg. 2019 Oct;25(5):608-611. doi: 10.1016/j.fas.2018.06.002. Epub 2018 June 26.
31. Bevernage BD, Leemrijse T. Hallux varus: classification and treatment. Foot and Ankle Clinics. 2009 Mar;14(1):51-65. doi: 10.1016/j.fcl.2008.11.007.
32. Kannegieter E, Kilmartin TE. The combined reverse scarf and opening wedge osteotomy of the proximal phalanx for the treatment of iatrogenic hallux varus. The Foot. 2011 Jun;21(2):88-91. doi: 10.1016/j.foot.2011.01.011. Epub 2011 Feb 11.
33. Maceira E, Monteagudo M. Transfer Metatarsalgia Post Hallux Valgus Surgery. Foot Ankle Clin N Am. 2014 Jun;19(2):285-307. doi: 10.1016/j.fcl.2014.03.001.
34. Murawski C, Egan C, Kennedy J. A Rotational Scarf Osteotomy Decreases Troughing When Treating Hallux Valgus. Clin Orthop Relat Res. 2011 Mar;469(3):847-53. doi: 10.1007/s11999-010-1647-3. Epub 2010 Oct 26.
35. Lee S, Hwang S, Nam C, Baek J, Yoo S, Ahn H. Technique for Preventing Troughing in Scarf Osteotomy. The Journal of Foot & Ankle Surgery. 2017 Jul-Aug;56(4):822-823. doi: 10.1053/j.jfas.2017.01.051. Epub 2017 May 4.
36. Lopez F, Reilly I, Murphy L. The Scarf Osteotomy: A technique variant: The trotation scarf and Akin osteotomies for hallux valgus: Short term results of 73 cases. The Foot and Ankle Online Journal. 2015; 8(1);p3. http://faoj.org/2015/03/31/the-scarf-osteotomy-a-technique-variant-the-trotation-scarf-and-akin-osteotomies-for-hallux-valgus-short-term-results-of-73-cases/
37. Bock P, Lanz U, Kroener A, Grabmeier G, Engel A. The Scarf Osteotomy. A Salvage Procedure for Recurrent Hallux Valgus in Selected Cases. Clin Orthop Relat Res. 2010 Aug;468(8):2177-87. doi: 10.1007/s11999-010-1363-z. Epub 2010 May 22.
38. Jones S, Al Hussainy H, Ali F, Betts R, Flowers M. Scarf osteotomy for hallux valgus: a prospective clinical and pedobaroGraphic study. J Bone Joint Surgery. 2004 Aug;86(6):830-6. doi: 10.1302/0301-620x.86b6.15000.
39. Seng C, Chunyin Ho D, Chong K. Restoring Sesamoid Position in Scarf Osteotomy: A Learning Curve. The Journal of Foot & Ankle Surgery. 2015 Nov-Dec;54(6):1089-92. doi: 10.1053/j.jfas.2015.07.001. Epub 2015 Aug 28.
40. Bock P, Kluger R, Kristen K, Mittlbock M, Schuh R, Trnka HJ. The Scarf Osteotomy with Minimally Invasive Lateral Release for Treatment of Hallux Valgus Deformity: Intermediate and Long-Term Results. J Bone Joint Surg Am. s2015 Aug 5;97(15):1238-45. doi: 10.2106/JBJS.N.00971.
41. Hirao M, Ebina K, Suboi H. Modified Scarf Osteotomy with Medial Capsular Interposition in Great Toe and Metatarsal Shortening Offset Osteotomy in Lesser Toes for Rheumatoid Deformity. JBJS Essent Surg Tech. 2018 Oct 24;8(4):e27. doi: 10.2106/JBJS.ST.18.00004. eCollection 2018 Dec 26.

Sažetak

## KOREKCIJA HALUKSA VALGUSA "SCARF" OSTEOTOMIJOM PRVE METATARZALNE KOSTI - NAŠA ISKUSTVA, PREDNOSTI I OGRANIČENJA METODE

*H. Klobučar, B. Strahonja* i *D. Tršek*

Istraživanje analizira scarf osteotomiju u liječenju hallux valgus deformacije. Studija analizira 175 izoliranih scarf osteotomija prve metatarzalne kosti (sa/bez Akin osteotomije) koje je izveo jedan operater. Radiološka (intermetatarzalni kut-IMA, hallux valgus kut-HVA, distalni-metatarzalni zglobni kut-DMAA, proksimalno-distalni falangealni-zglobni kut-PDPAA, translacija dijafize i položaj sezamoida) i klinička (Foot and Ankle Disability Indeks-FADI i American Orthopedic Foot and Ankle Score-AOFAS) procjena napravljena je prije i poslije liječenja. Praćenje je trajalo 1-10 godina. HVA se smanjio za 24°-sa 32°±8,8(16°-60°) na 8°±7,4(-27°-32°), IMA za 11°-sa 15°±3,7(16 °-31°) do 4°±2,4(0°-13°), DMAA za 12°-od 17° do 5°, PDPAA za 5°-od 5° do 0° i sezamoidni položaj od 5(2- 7) do 1(1-7). Metatarzalna translacija je 58%±14,5(17%-94%). FADI je povećan sa 65±18.2(26-99) na 95±9,7(45-100) i AOFAS sa 76±9, na 6(47-98) 96±6,9(72-100). Sve su razlike bile značajne ($p<0,05$). Bilo je 4,6% recidiva, jatrogenih haluks varusa 6,3%, simptomatski vijak 9%, transferna metatarzalgija 2,3%, troughing 2,9%, infekcija površinske rane 1,1% i postoperativna hipestezija 1,1%. Scarf osteotomija je pouzdan i siguran postupak za korekciju umjerenih do teških haluks valgus deformiteta. Relativno duga krivulja učenja opterećena je rješivim komplikacijama.

Ključne riječi: *scarf osteotomija, hallux valgus, osteotomija prve metatarzalne kosti, scarf krivulja učenja*