Clinical Research on Foot & Ankle
ISSN: 2329-910X

Research Article Open Access

Relevancy grading of outcome predicting factors after distal chevron osteotomy for hallux valgus correction

Gerhard Kaufmann[1], Moritz Wagner[2]*, Dietmar Dammerer[3], Hanno Ulmer[4], Michael Liebensteiner[5], Franz Endstrasser[6] and Matthias Braito[7]

[1]*OFZ Innsbruck, Innrain 2/3 Stock, 6020 Innsbruck, Austria*
[2]*Department of Orthopedic Surgery, District Hospital St. Johann, Bahnhofstraße 14, 6380 St. Johann, Austria*
[3]*Department of Orthopaedics and Traumatology, University Hospital Krems, Mitterweg 10, 3500 Krems an der Donau, Austria*
[4]*Department of Medical Statistics, Informatics and Health Economics, Medical University of Innsbruck, Anichstrasse 35, 6020 Innsbruck, Austria*
[5]*Department of Orthopedic Surgery, Medical University of Innsbruck, Anichstrasse 35, 6020 Innsbruck, Austria*
[6]*Department of Orthopedic Surgery, District Hospital St. Johann, Bahnhofstraße 14, 6380 St. Johann, Austria*
[7]*Department of Orthopedic Surgery, District Hospital St. Johann, Bahnhofstraße 14, 6380 St. Johann, Austria*

Abstract

Aim: The purpose of this study was to identify radiographic risk factors for loss of correction (LOC) after hallux valgus surgery and to weight their importance for LOC.

Patients and Methods: We retrospectively assessed radiographs of 1082 consecutive chevron osteotomy cases in regard to early LOC from initially postoperative to six and 12 weeks postoperatively. The influence of preoperative and postoperative radiographic parameters on LOC of hallux valgus angle (HVA) and intermetatarsal 1/2 angle (IMA) was evaluated using nonparametric Spearman's rank correlations and multiple linear regression analyses.

Results: Mean LOC from initially postoperative to six and 12 weeks postoperatively were 1.4 (SD 2.7) and 3.4 (SD 2.6) degrees for IMA and 3.5 (SD 5.4) and 7.6 (SD 5.6) degrees for HVA, respectively. Significant correlations were found between LOC of HVA and IMA for preoperative IMA, HVA, distal metatarsal articular angle (DMAA), proximal to distal phalangeal articular angle (PDPAA) and joint congruity as well as for postoperative IMA, HVA, PDPAA, joint congruity and sesamoid position. Categorization of outcome-predicting postoperative radiographic factors revealed the following parameters to be important in descending order: HVA, sesamoid position, IMA, PDPAA and joint congruity.

Conclusion: Multiple pre- and postoperative radiological parameters correlate with early loss of correction after hallux valgus surgery. Relevancy grading revealed the postoperative HVA and sesamoid position to be the most important parameters, followed by IMA, PDPAA and joint congruity. In consequence total deformity correction, taking all aspects of the hallux valgus deformity into account, seems reasonable.

Take home message: Total deformity correction taking into account all aspects of the hallux valgus deformity (severity of hallux valgus deformity, joint line orientation and joint congruity, hallux valgus interphalangeus, positioning of the sesamoids) may result in reduced early LOC after distal chevron osteotomy for hallux valgus correction.

Keywords: Hallux valgus; Total deformity correction; Loss of correction; Radiological outcome

Abbreviations: DMAA - Distal metatarsal articular angle; HVA - Hallux valgus angle; IMA - Intermetatarsal angle; LOC-Loss of correction, PDPAA-Proximal to distal phalangeal articular angle; Po - Postoperative

Article Summary

Article focus

- Retrospective radiographic analysis of 1082 consecutive chevron osteotomy cases was performed
- Loss of reduction for intermetatarsal 1/2 angle and hallux valgus angle was assessed until three months after surgery

Key messages

- Mean loss of reduction was 3.4 (SD 2.6) degrees for intermetatarsal 1/2 angle and 7.6 (SD 5.6) degrees for the hallux valgus angle
- Multiple pre- and postoperative radiological parameters correlate with early loss of reduction, postoperative hallux valgus angle and sesamoid positions were the most prognostic factors.

Strength and limitations of this study

- Limitations of this study include its retrospective design and the fact that this was a single-center study.
- Strengths of this study include the large sample size and the standardized outcome measurements.

Introduction

Hallux valgus deformity is characterized as a deformity and malpositioning of the greater toe composed of different pathological entities, which need to be assessed separately [1]. First of all, the amount of the lateral deviation of the greater toe and the medial deviation of the first metatarsal bone can be quantified by measuring the intermetatarsal 1/2 angle (IMA) and the hallux valgus angle (HVA). The joint line orientation expressed by the distal metatarsal articular

***Corresponding author:** Moritz Wagner, Department of Orthopedic Surgery, District Hospital St. Johann, Bahnhofstraße 14, 6380 St. Johann, Austria, Tel: +4367762930592; E-mail: moritz.wanger@gmail.com

Received: 09-Jan-2022, Manuscript No. CRFA-22-51423; **Editor assigned:** 11-Jan-2022, PreQC No. CRFA-22-51423 (PQ); **Reviewed:** 22-Jan-2022, QC No. CRFA-22-51423; **Revised:** 25-Jan-2022, Manuscript No. CRFA-22-51423 (R); **Published:** 31-Jan-2022, DOI: 10.4172/2329-910X.1000330

Citation: Kaufmann G, Wagner M, Dammerer D, Ulmer H, Liebensteiner M, et al. (2022) Relevancy grading of outcome predicting factors after distal chevron osteotomy for hallux valgus correction32. Clin Res Foot Ankle, 10: 330.

angle (DMAA) is a second aspect of the deformity. Third, a hallux valgus interphalangeus deformity, expressed by the proximal to distal phalangeal articular angle (PDPAA), and fourth, the malaligned soft tissue structures, expressed by the sesamoid position and the joint congruity of the metatarsophalangeal joint, contribute to the hallux valgus deformity as well. In consequence, surgical hallux valgus correction needs to address every aspect of the deformity to achieve good results resulting in total deformity correction [2,3].

Outcomes after hallux valgus correction is still discussed controversially [4]. Although good clinical outcome can be observed with most surgical techniques [5-9], a major complication after hallux surgery remains recurrence, which is usually defined as a postoperative hallux valgus angle (HVA) exceeding 15-20 degrees [3,10]. Early loss of correction (LOC) with deterioration of certain radiological parameters between the initial postoperative radiograph and the radiographs within the first three months can be observed frequently after surgery. It can be presumed, that early loss of correction may result in recurrence of the hallux valgus deformity.

Several studies have identified preoperative as well as postoperative radiographic parameters with influence on outcome after bunion surgery already [7,9-16]. However, no study has categorized the contributing factors in relation to their impact on LOC to date. Therefore, the purpose of this study was to analyze the specific contribution of each radiographic parameter on early LOC after hallux valgus correction.

Patients and Methods

The study was performed in accordance with the ethical standards outlined in the 1964 World Medical Association Declaration of Helsinki and its later amendments. The study was approved by the local ethics committee UN5080 and registered with the local trial registry (20200215-2202).

Data was collected retrospectively from adult patients who underwent an isolated hallux valgus correction between January 2002 and December 2012 at our department. Data were collected via electronic search by means of the ICD (International Statistical Classification of Diseases and Related Health Problems, WHO) and the MEL code (benefit-related coding system in national hospitals, National Ministry of Health). The applied surgical methods were identified by controlling the medical chart of every listed patient.

Exclusion criteria were (1) patients with incomplete radiological follow-up, (2) patients with additional surgery (e.g. metatarsal osteotomy for the lesser rays, hammer toe surgery) to prevent secondary effects on the assessed radiographic parameters, (3) patients with preoperative HVA of less than 20 degrees or an IMA of less than 10 degrees following the definition of a hallux valgus deformity [17-19], and (4) patients under the age of 18 years to exclude juvenile hallux deformity.

Hallux valgus correction was performed in a total 2684 feet during the study period. 1546 adult feet could be identified with an isolated correction of the first ray for hallux valgus deformity and no additional osteotomies of the other metatarsals. It presents the participant flow chart of the included patients. After exclusion of 77 feet because of an incomplete radiological data set and 387 feet treated with osteotomies other than a chevron osteotomy, a total of 1082 feet (134 male feet, 948 female feet; 550 right feet, 532 left feet) were available for final evaluation. In this group 153 (14.1%) feet had undergone an additional phalangeal osteotomy of the greater toe (akin osteotomy). Mean age at time of surgery was 52.4 years (SD 14.7).

Radiographic Evaluation

At the following time points radiographs are taken as part of our clinical routine: Preoperatively, initially after surgery and six and 12 weeks postoperatively. All radiographs were taken in a standardized manner in two planes with the patient in a standing position.

Radiographs were analyzed in digital manner with the Icoview software (syngo.share, ITH icoserve healthcare GmbH, Siemens) by a trained foot and ankle fellow, who was not involved in patients' care and advised by a senior orthopedic surgeon. The following radiographic outcome measurements were used for this study and have been described previously [9]: (1) the hallux valgus angle (HVA), (2) the intermetatarsal 1/2 angle (IMA), (3) the distal metatarsal articular angle (DMAA), (4) the proximal to distal phalangeal articular angle (PDPAA), (5) the position of the tibial sesamoid in relation to the midshaft axis of the first metatarsal (7-part grading system) [17], and (6) the joint congruity of the greater toe joint (angle between the joint lines of the articular surface of the metatarsal head and the base of the proximal phalangeal bone).

Surgical Technique

The exact operative techniques for the chevron and akin osteotomy have been described before [9]. A distal soft tissue procedure including a release of the metatarsosesamoidal ligament and a T-shaped capsulotomy of the lateral capsule of the greater toe joint was performed in every case to allow repositioning of the sesamoids.

Postoperative management was standardized for all cases. To maintain the position of the greater toe, soft dressings were applied for six weeks. Patients were mobilized immediately in a custom-made hallux valgus shoe (Ofa GmbH, Bamberg, Germany). The surgical shoe was discarded after six weeks. After reduced weight-bearing for two weeks progression to full weight-bearing was recommended.

Statistical Method

All statistical analyses were conducted with SPSS 20.0 (International Business Machines Corporation, Armonk, NY, USA). Sample characteristics are given as means with ranges or medians with interquartile range and frequencies for categorical data. A p-value < 0.05 was considered statistically significant.

Tested pre and postoperative radiographic parameters included IMA, HVA, PDPAA, DMAA, sesamoid position, and joint congruity. In a first step, each parameter was correlated with LOC of IMA and HVA after 6 and 12 weeks using nonparametric Spearman's rank correlation. Additionally, relevancy grading of each of these parameters was performed in regard to its influence on LOC. According to Cohen, correlation coefficients in the order of r=0.10 were defined as "small," those of r=0.30 as "medium," and those of r=0.50 as "large" in terms of magnitude of effect size.

In hallux valgus correction all parameters contributing to the deformity should be addressed in terms of total deformity correction. In regard to the assumption, that all preoperative parameters have been surgically addressed, we think that the preoperative parameters might be of minor importance on LOC and LOC should be dependent from the postoperative parameters only. In consequence, we only assessed the postoperative radiographic parameters to determine the most influential postoperative radiological parameters on outcome using a regression analysis. Thus, in a second step only for the postoperative parameters a multiple linear regression analysis was performed to evaluate the importance of each parameter on LOC. Standardized beta coefficients were given together with p-values. The strength of the association between a predictor and an outcome variable is expressed by beta coefficients, meaning that one standard deviation of change in a predictor variable leads to a change of one unit of the outcome variable. The analysis of different radiographic parameters and LOC showed statistical power above 90% to detect differences of 0.1 SD with a 5% level for statistical significance.

Results

Mean LOC of IMA from initially postoperative to six weeks postoperatively were 1.4 (SD 2.7), from postoperatively to 12 weeks 3.4 degrees (SD 2.6). LOC of HVA amounted to and 3.5 (SD 5.4) and 7.6 degrees (SD 5.6) respectively.

Multiple significant correlations between different radiological parameters and LOC were detected in our cohort. Tables 1 and 2 present the p-values of all tested radiographic parameters for LOC of HVA and IMA. Significant correlations (Pearson´s correlation at the 0.01 level) were found between LOC of HVA and preoperative HVA, IMA, DMAA and joint congruity as well as for postoperative HVA, PDPAA, joint congruity and sesamoid position. For preoperative sesamoid position as well as for postoperative IMA and DMAA a correlation with minor significance could be detected (Pearson´s correlation at the 0.05 level) as well.

The results of the multiple linear regression analysis of the individual radiographic postoperative parameters with regard to LOC from postoperative to six weeks are presented in Table 3 and from six to 12 weeks in Table 4. Radiographic parameters correlating with LOC of HVA with significance (p<0.001) at 6 weeks were HVA, DMAA and PDPAA, at 12 weeks for HVA only. LOC of IMA correlated significantly at 6 weeks with HVA, IMA and joint congruity, at 12 weeks only with HVA. The radiographic parameters in descending order in regard to their specific importance on LOC from postoperative to 6 weeks postoperative (Table 3) were DMAA, PDPAA, joint congruity (with significance p<0.001) and sesamoid position. For IMA and HVA only an indirect correlation could be found. The parameters in descending order from six to 12 weeks (Table 4) were HVA and sesamoids with significance (p<0.001), followed by IMA, PDPAA and joint congruity. For DMAA only an indirect correction could be detected. Interestingly, postoperative HVA and IMA showed an indirect correlation with LOC after 6 weeks, postoperative DMAA after 12 weeks.

Discussion

We regard the identification and effect sizing of the postoperative radiographic parameters as the most important finding of our study. We could identify the DMAA, PDPAA and joint congruity to be the most relevant factors correlating with LOC after 6 weeks and HVA and the sesamoid position after 12 weeks. In other words, besides the

Table 1: Associations of radiographic parameters with LOC of HVA.

	LOC HVA po to 6 weeks		LOC HVA 6 to 12 weeks po	
preoperative parameter	**Pearson correlation**	**p-value**	**Pearson correlation**	**p-value**
IMA	.094**	.005	.025	.434
HVA	.093**	.005	.116**	<.001
DMAA	.004	.896	.090**	.005
sesamoid position	.080*	.015	-.002	.575
joint congruity	.094**	.005	.038	.238
PDPAA	-.027	.410	-.016	.620
postoperative parameter	**Pearson correlation**	**p-value**	**Pearson correlation**	**p-value**
IMA	-.108**	<.001	.075*	.019
HVA	-.368**	<.001	.150**	<.001
DMAA	.081*	.013	-.001	.982
sesamoid position	-.013	.693	.140**	<.001
joint congruity	.084**	.009	.009	.788
PDPAA	.086**	.008	-.054	.092

* Correlation is significant at the 0.05 level (2-tailed)
** Correlation is significant at the 0.01 level (2-tailed)

Table 2: Associations of radiographic parameters with LOC of IMA.

	LOC IMA po to 6 weeks		LOC IMA 6 to 12 weeks po	
preoperative parameter	**Pearson correlation**	**p-value**	**Pearson correlation**	**p-value**
IMA	.170**	<.001	.032	.328
HVA	.996	<.001	.040	.196
DMAA	-.044	.169	-.031	.313
sesamoid position	-.038	.238	-.048	.121
joint congruity	.041	.198	.095**	.002
PDPAA	.139**	<.001	.144**	<.001
postoperative parameter	**Pearson correlation**	**p-value**	**Pearson correlation**	**p-value**
IMA	-.384**	<.001	.197**	<.001
HVA	-.242**	<.001	.228**	<.001
DMAA	.063	.051	-.048	.142
sesamoid position	-.135	<.001	.139**	<.001
joint congruity	.158**	<.001	-.089**	.006
PDPAA	.046	.155	-.032	.320

* Correlation is significant at the 0.05 level (2-tailed)
** Correlation is significant at the 0.01 level (2-tailed)

Table 3: Predictors for LOC at 6 weeks postoperatively evaluated with multiple regression analysis.

predictor	LOC HVA		LOC IMA	
	standardized beta coefficient	p-value	Standardized beta coefficient	p-value
postoperative HVA	-0.476	<.001	-0.169	<.001
postoperative IMA	0.038	0.248	-0.323	<.001
postoperative DMAA	0.203	<.001	0.051	0.113
postoperative PDPAA	0.172	<.001	0.061	0.044
postoperative Congruity	0.025	0.417	0.12	<.001
postoperative sesamoids	0.074	0.019	0.015	0.636
R-squared = 20.3% LOC HVA; R-squared = 18.7% LOC IMA				

Table 4: Predictors for LOC from 6 to 12 weeks postoperatively evaluated with multiple regression analysis.

predictor	LOC HVA		LOC IMA	
	standardized beta coefficient	p-value	standardized beta coefficient	p-value
postoperative HVA	0.16	<.001	0.218	<.001
postoperative IMA	-0.018	0.615	0.095	0.007
postoperative DMAA	-0.049	0.162	-0.084	0.014
postoperative PDPAA	0.085	0.009	0.066	0.038
postoperative Congruity	0.015	0.645	0.064	0.049
postoperative sesamoids	0.114	<.001	0.063	0.064
R-squared = 4.3% for LOC HVA; R-squared = 8.8% for LOC IMA				

restauration of the foot shape (HVA), the correction of the joint line in terms of the DMAA, the correction of a phalangeal deformity in terms of the PDPAA and the restauration of the soft tissue pathology in terms of the sesamoid position and the joint congruity are essential for successful hallux valgus correction.

A second important finding was that for all preoperative parameters a correlation either to LOC of HVA or IMA could be detected. This finding supports the idea of total deformity correction in hallux valgus surgery [1].

Our findings are well in line with the published literature. Multiple parameters correlating with LOC and recurrence after hallux valgus surgery have been identified so far. For preoperative IMA, preoperative PDPAA, postoperative HVA and IMA, postoperative DMAA, postoperative sesamoid position, and postoperative joint congruity an influence on LOC has been proven already [7,9,20].

For numerous surgical techniques of hallux valgus correction, a dependence of certain factors has been found. Distal chevron osteotomy showed a correlation of preoperative IMA, HVA, DMAA, joint congruity and sesamoid position with LOC [10,21-22]. After scarf osteotomy the preoperative DMAA correlated with LOC [23], whereas hallux valgus recurrence was influenced by the preoperative joint congruity [11,15]. Park et al. identified preoperative HVA as well as insufficient correction of the HVA and sesamoid position as risk factors for hallux valgus recurrence after proximal metatarsal osteotomy [13]. Another study has found a direct correlation between long-term hallux valgus recurrence after distal chevron osteotomy and preoperative joint congruity, DMAA, sesamoid position, HVA, and IMA [10]. In this study radiological recurrence of hallux valgus deformity (HVA > 15 degrees) was observed in three-quarters of cases, but interestingly no revision surgery has been recorded. Similar to our study Shibuya et al. focused on early LOC after hallux valgus surgery [21]. The only factor associated with LOC in their study was a postoperative tibial sesamoid position of more than 4 on a 7-point scale. The importance of the postoperative sesamoid position was identified as outcome-predicting factor after proximal metatarsal osteotomy as well [14]. However, although the postoperative sesamoid position had an influence on outcome, a significant correlation with hallux valgus recurrence could not be found so far [24]. In conclusion, in the published literature as well as in our study for all radiographic parameters a correlation with outcome after hallux valgus correction was found.

However, to our knowledge no previous study has focused on analyzing the most influential factors of LOC following hallux valgus correction. In accordance to the study of Park the immediate postoperative radiographs in our study were non-weight-bearing as well [13]. LOC was calculated as the change in regard to these radiographs. With our multiple regression analysis we found significant correlations between early LOC (after 6 weeks) and postoperative DMAA, PDPAA and joint congruity. Correlation with medium effect size was found for postoperative sesamoid position. For IMA and HVA an indirect correlation was detected. LOC after 12 weeks showed significant correlation with postoperative HVA and sesamoid position, correlation with medium effect size for IMA, PDPAA and joint congruity. For DMAA an indirect correlation could be detected. Interestingly, all postoperative radiographic parameters, with exception of the IMA, correlated significantly either with LOC of HVA or LOC of IMA. Postoperative IMA and HVA showed an indirect correlation to LOC after 6, DMAA after 12 weeks. This finding means that higher amounts of IMA and HVA correction resulted in higher LOC within the first 6 weeks and higher LOC after 12 weeks for higher amounts of DMAA correction. This might be explained with the following. More severe deformities allow for higher amounts of correction and may be accompanied by a tendency toward higher LOC as well.

The results of our multiple regression analysis indicate in descending order of importance the postoperative DMAA (significant), postoperative PDPAA (significant) and postoperative joint congruity (significant) to be the most influential parameters for LOC after 6 weeks, followed by the postoperative sesamoid position (almost significant), the postoperative PDPAA (almost significant) and the joint congruity. In contrast, after 12 weeks the most predictive parameters were the postoperative HVA and postoperative sesamoid position (with significance), followed by postoperative IMA and PDPAA (almost significant) and postoperative joint congruity.

Our study describes the preoperative IMA and HVA as well as the postoperative HVA as substantial factors for LOC after hallux valgus correction. Various studies have already shown a dependency of radiological outcome after hallux valgus correction of the IMA [7,9,22]. Our study provides additional data for supporting the idea that the surgical method should be chosen in regard to the severity of the preoperative deformity in terms of IMA and HVA.

Hallux valgus interphalangeus deformity has been presumed to substantially contribute to the total hallux valgus deformity[1]. It has been shown already, that the additional correction of a phalangeal pathology results in better outcome after hallux valgus correction [7,9]. In this study, we were able to detect a correlation between the pre- and postoperative PDPAA and LOC of HVA and IMA. This finding is regarded to be essential, as it can be assumed that a successful correction of hallux valgus interphalangeus, as determined by the PDPAA, reduces the risk of LOC after hallux valgus surgery. In a previous study, postoperative IMA correlated significantly with radiological outcome after combined scarf and akin osteotomy, whereas after scarf osteotomy without correction of an additional hallux valgus interphalangeus deformity, both PDPAA and IMA correlated with outcome [7]. Therefore, the results of our studies support the application of an additional akin osteotomy in cases of a hallux valgus interphalangeus deformity.

Additionally, we found a correlation of the sesamoid position and the joint congruity, which both represent the soft tissue pathology in hallux valgus deformities. Pathological joint congruity [11] has been linked to poorer radiological outcome after hallux valgus correction already. For DMAA a correlation could be detected with our study as well. This parameter has been shown to influence outcome after hallux valgus correction as well [19,23,25].

In summary, our study supports the idea of total deformity correction in hallux valgus correction. Every contributing pathology of the hallux valgus deformity has to be addressed adequately to reduce the risk of LOC and recurrence. Successful hallux valgus correction comprises selecting an effective metatarsal osteotomy technique depending on preoperative IMA, correction of DMAA in terms of restoration of the joint line, correction of an additional hallux valgus interphalangeus deformity defined by the PDPAA, and realignment of the soft tissue structures expressed by the joint congruity and the position of the sesamoids.

Strengths and Limitations

The limitations of this study stem from the monocentric character, the retrospective nature, and the single-measurement analysis of the radiographs. Furthermore, the influence of early LOC on hallux valgus recurrence and revision surgery has not been investigated so far.

The most positive aspect remains the size of the analyzed data pool and the fact that all measurements were performed by an experienced fellow in foot and ankle surgery, therefore avoiding inter-observer variability.

Conclusion

Multiple pre- and postoperative radiological parameters correlate with early loss of correction after hallux valgus surgery. Relevancy grading revealed the postoperative HVA and sesamoid position to be most important parameters, followed by DMAA, PDPAA and joint congruity. In consequence total deformity correction, taking all aspects of the hallux valgus deformity into account, seems reasonable.

References

1. Strydom A, Saragas NP, Ferrao PNF (2017) A radiographic analysis of the contribution of hallux valgus interphalangeus to the total valgus deformity of the hallux. Foot Ankle Surg 23(1): 27-31.
2. Hart A, Janz V, Trousdale RT, Sierra RJ, Berry DJ, et al. (2019) Long-Term Survivorship of Total Hip Arthroplasty with Highly Cross-Linked Polyethylene for Osteonecrosis. J Bone Jt Surg 101(17):1563-1568.
3. Bock P, Kluger R, Kristen KH, Mittlbock M, Schuh R, et al. (2014) The scarf osteotomy with minimally invasive lateral release for treatment of hallux valgus deformity intermediate and long-term results. J Bone Jt Surg 97(15):1238-1245.
4. Deenik AR, Van Mameren H, De Visser E, Malefijt MDW, Draijer F, et al. (2008) Equivalent correction in scarf and chevron osteotomy in moderate and severe hallux valgus: A randomized controlled trial. Foot Ankle Int 29(12):1209-1215.
5. Adam SP, Choung SC, Gu Y, O'Malley MJ (2011) Outcomes after scarf osteotomy for treatment of adult hallux valgus deformity. Clin Orthop Relat Res 469(3):854-859.
6. Braito M, Dammerer D, Hofer-Picout P, Kaufmann G (2019) Proximal Opening Wedge Osteotomy With Distal Chevron Osteotomy of the First Metatarsal for the Treatment of Moderate to Severe Hallux Valgus. Foot Ankle Int 40(1):89-97.
7. Kaufmann G, Hofmann M, Ulmer H, Putzer D, Hofer P, et al. (2019) Outcomes after scarf osteotomy with and without Akin osteotomy a retrospective comparative study. J Orthop Surg Res 14(1).
8. Thordarson DB, Rudicel SA, Ebramzadeh E, Gill LH (2001) Outcome study of hallux valgus surgery - An AOFAS multi-center study. Foot Ankle Int 22(12):956-959.
9. Kaufmann G, Sinz S, Giesinger JM, Braito M, Biedermann R, et al. (2019) Loss of Correction After Chevron Osteotomy for Hallux Valgus as a Function of Preoperative Deformity. Foot Ankle Int. 2019;40(3):287-296.
10. Pentikainen I, Ojala R, Ohtonen P, Piippo J, Leppilahti J (2014) Preoperative radiological factors correlated to long-term recurrence of hallux valgus following distal chevron osteotomy. Foot Ankle Int 35(12):1262-1267.
11. Deveci A, Firat A, Yilmaz S, Oken OF, Yildirim AO, et al. (2013) Short-term Clinical and Radiologic Results of the Scarf Osteotomy: What Factors Contribute to Recurrence? J Foot Ankle Surg 52(6):771-775.
12. Li X, Guo M, Zhu Y, Xu X (2018) The excessive length of first ray as a risk factor for hallux valgus recurrence. PLoS One 13(10).
13. Park CH, Lee WC (2017) Recurrence of Hallux Valgus Can Be Predicted from Immediate Postoperative Non-Weight-Bearing Radiographs. J Bone Jt Surg 99(14):1190-1197.
14. Okuda R, Kinoshita M, Yasuda T, Jotoku T, Kitano N, et al. (2009) Postoperative incomplete reduction of the sesamoids as a risk factor for recurrence of hallux valgus. J Bone Jt Surg 91(7):1637-1645.
15. Castioni D, Fanelli D, Gasparini G, Iannò B, Galasso O (2020) Scarf osteotomy for the treatment of moderate to severe hallux valgus: Analysis of predictors for midterm outcomes and recurrence. Foot Ankle Surg 26(4):439-444.
16. Chen JY, Rikhraj K, Gatot C, Lee JYY, Singh Rikhraj I (2016) Tibial Sesamoid Position Influence on Functional Outcome and Satisfaction after Hallux Valgus Surgery. Foot Ankle Int 37(11):1178-1182.
17. Hardy RH, Clapham JC (1951) Observations on hallux valgus; based on a controlled series. J Bone Joint Surg Br 33 B(3):376-391.
18. Venning P (1951) Sources of error in the production and measurement of standard radiographs of the foot. Br J Radiol 24(277):18-26.
19. Coughlin MJ (1997) Hallux valgus in men: Effect of the distal metatarsal articular angle on hallux valgus correction. Foot Ankle Int 18(8):463-470.
20. Kaufmann G, Hofmann M, Braito M, Ulmer H, Brunner A, et al. (2019) Need for concomitant Akin osteotomy in patients undergoing Chevron osteotomy can be determined preoperatively: A retrospective comparative study of 859 cases. J Orthop Surg Res 14(1).
21. Shibuya N, Kyprios EM, Panchani PN, Martin LR, Thorud JC, et al. (2018) Factors Associated With Early Loss of Hallux Valgus Correction. J Foot Ankle Surg 57(2):236-240.
22. Kaufmann G, Hofer P, Braito M, Bale R, Putzer D, et al. (2019) Effect of Akin Osteotomy on Hallux Valgus Correction After Scarf Osteotomy With Hallux Valgus Interphalangeus. Foot Ankle Int 40(10):1182-1188.
23. Kaufmann G, Giesinger JM, Hofer P, Braito M, Biedermann R, et al. (2020) Does preoperative deformity diminish radiographic outcome after hallux valgus

correction with scarf osteotomy?: A retrospective study of 102 cases. Foot Ankle Surg 26(4):425-431.

24. Shi GG, Henning P, Marks RM (2016) Correlation of postoperative position of the sesamoids after chevron osteotomy with outcome. Foot Ankle Int 37(3):274-280.

25. Coughlin MJ, Carlson RE (1999) Treatment of hallux valgus with an increased distal metatarsal articular angle: Evaluation of double and triple first ray osteotomies. Foot Ankle Int 20(12):762-770.