Original Articles

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Surgical treatment of grade-3 hallux rigidus, joint-sparing approach and long-term results

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I**Introduction** Hallux rigidus (HR) is the second most common disease of the great toe affecting the first metatarso-phalangeal joint (MTPJ) and is characterized by a painful and stiff joint. Cheilectomy is considered the gold standard treatment for early stages of HR. The objective of the study was to evaluate the functional results of cheilectomy as a standalone procedure or in conjunction with great toe proximal phalangeal osteotomy (P1) and/or first metatarsal osteotomy (M1) performed for patients with grade-3 HR according to the Coughlin and Shurnas classification. **Material and methods** The study included retrospective review of 17 patients (20 feet) with grade 3 HR using the Coughlin and Shurnas Grading Scale who underwent operative treatment between September 2010 and January 2017. The patients' mean age was 52 years (range, 39 to 66 years). The median interval between surgery and the last follow-up was 5 years (interquartile range, 4.5 to 7.5 years). Outcome assessment relied on patient satisfaction, radiographic examination, visual analogue scale (VAS), the American Orthopaedic Foot & Ankle Society (AOFAS) and the Foot and Ankle Ability Measure (FAAM) scores. **Results** AOFAS score was rated as excellent in 90 % of the cases (18/20) and good in 10 % (2/20) with neither fair nor poor results recorded. The median AOFAS score increased from preoperative 60.0 points to postoperative 97.0 points that was statistically significant ($p < 0.05$). Postoperative median FAAM Activities of Daily Living (ADL) and median subjective ADL was 100 %, median FAAM sport was 97 %, and median subjective sport was 90 %. Patient subjective assessment was scored as excellent in 60 % of cases (12/20), good in 40 % (8/20) with neither fair nor poor results recorded. The median VAS pain score decreased from 6 points at baseline to 1 point postsurgery ($p < 0.05$). Measurement of the first MTP dorsiflexion showed statistically significant increase in the median angle from 10° at baseline to 40° postsurgery ($p < 0.05$). **Conclusion** Cheilectomy as a standalone procedure or in conjunction with P1 osteotomy and/or M1 osteotomy has demonstrated 100% positive long-term outcomes for patients with Coughlin and Shurnas grade-3 HR. The procedure can be advocated as a predictable and excellent option for the cohort of patients. First MTPJ decompression is to be considered with P1 osteotomy and/or M1 osteotomy for grade-3 HR patients in preoperative planning to ensure normal forefoot anatomy and can be an option for some cases of Coughlin and Shurnas grade-3 HR.

Keywords: hallux rigidus, first metatarsophalangeal joint osteoarthritis, cheilectomy, great toe proximal phalangeal osteotomy, first metatarsal osteotomy

INTRODUCTION

Hallux rigidus (HR) is a common degenerative joint condition affecting the first metatarso-phalangeal joint (MTPJ) that progresses over time resulting in limited functional activity. The management of HR initially is non-operative. If however, the patient is unlikely to benefit from non-operative treatments, surgical treatment can be offered. Surgical options for failed conservative treatment of HR include cheilectomy[1], arthrodesis of the first MTPJ [2], great toe proximal phalangeal osteotomy (P1) [3], first metatarsal osteotomy (M1) [4], interpositional arthroplasty [5], resection arthroplasty [6], metallic hemiarthroplasty [7] as well as plate fixation and implant arthroplasty [7, 8, 9, 10]. However, the optimal management is controversial. It is well accepted that cheilectomy may provide better outcomes at earlier stages of HR and arthrodesis or arthroplasty of the MTPJ are recommended for advanced disease. Surgical treatment of moderate HR remains controversial. Though a surgeon and a patient tend to opt for a joint-sparing procedure a joint-sacrificing procedure may be the preferred treatment option due to a greater risk of complication [2, 11, 12, 13]. We sought to evaluate the functional results of cheilectomy as a standalone procedure or combined with great toe proximal phalangeal osteotomy (P1) and/or first metatarsal osteotomy (M1) performed for patients with grade-3 HR according to the Coughlin and Shurnas classification. We used a classification approach developed by Coughlin and Shurnas in 1999 who proposed a 5-stage grading system (stage 0 to 4) for HR using symptoms and signs, radiographic findings and range of motion [2] (Table 1).

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Table 1

Coughlin and Shurnas' classification system for HR (ROM, range of motion; DF, dorsiflexion, PF, plantar flexion)

	CLINICAL PARAMETERS	RADIOLOGICAL FINDINGS
Grade 0	DF = 40–60°(< 20 % of normal ROM), no pain	Normal
Grade 1	DF = 30–40° (< 20–50 % of normal ROM), mild pain	Minimal dorsal osteophyte, normal joint space
Grade 2	DF = 10–30° (< 50–70 % of normal ROM), moderate exercise-related pain	Moderate dorsal (lateral/medial) osteophyte, joint space narrowing < 50 %, osteosclerosis
Grade 3	PF< 10° (often PF < 10°), pain at extremes of ROM of the first MTPJ but not at mid-motion	Severe dorsal osteophyte, joint space narrowing > 50 %, subchondral cysts or erosion, sesamoid hypertrophy or cystic/degenerative changes
Grade 4	Substantial stiffness, pain at extremes of ROM of the first MTPJ and at mid-range of passive motion	Severe dorsal osteophyte, joint space narrowing > 50 %, free bodies or osteochondral defects, sesamoids enlarged, cystic/degenerative

Coughlin and Shurnas recommended cheilectomy as the operative standard of care for Grades 1–3 HR and secured arthrodesis for Grade-4 cases. Grade-3 HR patients with less than 50% of the metatarsal head cartilage remaining at the time of surgery should be treated with arthrodesis, and cheilectomy can be used for the rest of the cases. Coughlin and Schurnas reported their experience with cheilectomy or MPJ arthrodesis in the treatment of HR. Cheilectomy patients (n = 80) showed the mean VAS score being decreased from 8 points at baseline to 1.5 points postsurgery, the mean AOFAS score being improved from 45 points before surgery to 90 points postsurgery; outcomes based on patient self-assessment were rated as excellent (n = 58), good (n = 19) and fair (n = 3) with no poor outcomes recorded. Dorsiflexion in the MTPJ improved from 14.5° at baseline to 63.7° postsurgery. Arthrodesis patients (n = 30) showed the mean VAS score being decreased from 8.7 points at baseline to 0.4 point postsurgery, the mean AOFAS score being improved from 38 points before surgery to 89 points postsurgery; outcomes based on patient self-assessment were rated as excellent (n = 26) and good (n = 4) with neither fair nor poor outcomes recorded. Dorsiflexion in the MTPJ improved from 14.5° at baseline to 63.7° postsurgery. Good to excellent results were reported in 97% of cases following cheilectomy and 100% of patient following first MTPJ fusion. Unfortunately, poorer reproducibility of the satisfying outcomes is seen in other series [7, 14, 15, 16, 17, 18].

The **purpose** of the study was to evaluate the functional results of cheilectomy as a standalone procedure or in conjunction with great toe proximal phalangeal osteotomy (P1) and/or first metatarsal osteotomy (M1) performed for patients with grade-3 HR according to the Coughlin and Shurnas classification.

MATERIAL AND METHODS

The study included retrospective review of 17 patients (20 feet) with Coughlin and Shurnas grade 3 HR who underwent operative treatment at the European Clinic of Sports Traumatology and Orthopedics (ECSTO), The European Medical Center (EMC) between September 2010 and January 2017. The patients' mean age was 52 years (range, 39 to 66 years). There were 15 female and 2 male patients. Patients were examined preoperatively and at a long term. The median interval between surgery and the last follow-up was 5 years (interquartile range, 4.5 to 7.5 years). Clinical evaluation, podoscopy and weight-bearing dorsiplantar and lateral radiographs of the feet were produced to diagnose HR in the patients. Clinical measurements of first MTPJ range of motion (ROM) and dorsiflexion were performed with goniometer in a standard manner (Fig. 1). Deformity of the first ray, degenerative changes in the MTPJ, joint space narrowing, dorsal osteophytes over the M1 head and at the base of P1 were radiologically evaluated. Subchondral cysts or erosion, subchondral sclerosis, free bodies or osteochondral defects, hypertrophied and degenerative sesamoids were quite common. Intermetatarsal angle and interphalangeal angle were important radiological parameters for surgical strategy. From our experience, the surgery should aim to provide adequate decompression in the joint due to sufficient shortening of M1 and/or P1 rather than greater ROM in first MTPJ (Fig. 2).

Aggressive cheilectomy and remodeling of the head M1 was performed if bone shortening was unnecessary or could not be produced (Fig. 3).

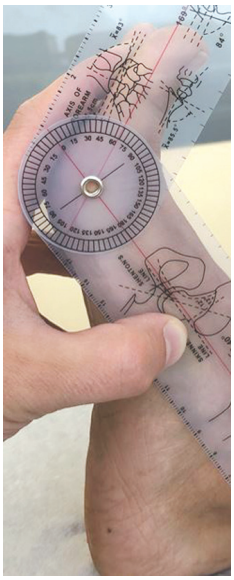

Fig. 1 Measuring ROM in first MTPJ with goniometer

Fig. 2 Preoperative (***a***) and postoperative (***b***) weight-bearing AP radiographs of the right foot. An arrow shows decompression in first MTPJ produced during cheilectomy in conjunction with osteotomy of M1

Fig. 3 Preoperative (***a***) and postoperative (***b***) weight-bearing AP radiographs of the right foot. The surgery performed included aggressive cheilectomy and remodeling of the head of M1

With the approach described above, the surgeries performed included standalone cheilectomy (n = 5), cheilectomy in conjunction with osteotomy of P1 (n = 7), cheilectomy and osteotomy of M1 (n = 3), cheilectomy and osteotomy of P1 and M1 (n = 5) (Fig. 4).

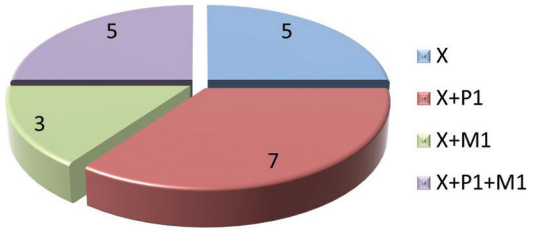

Fig. 4 Distribution of surgeries performed: cheilectomy (X), cheilectomy and osteotomy of P1 (X + P1), cheilectomy and osteotomy of M1 (X + M1), cheilectomy in conjunction with osteotomy of P1 and M1 (X + P1 + M1)

Hallux valgus interphalangeus was addressed with correcting osteotomy of P1 (Akin osteotomy) proximally, distally or metadiaphyseally for realignment and decompression of first MTPJ because of the first ray shortening (Fig. 5).

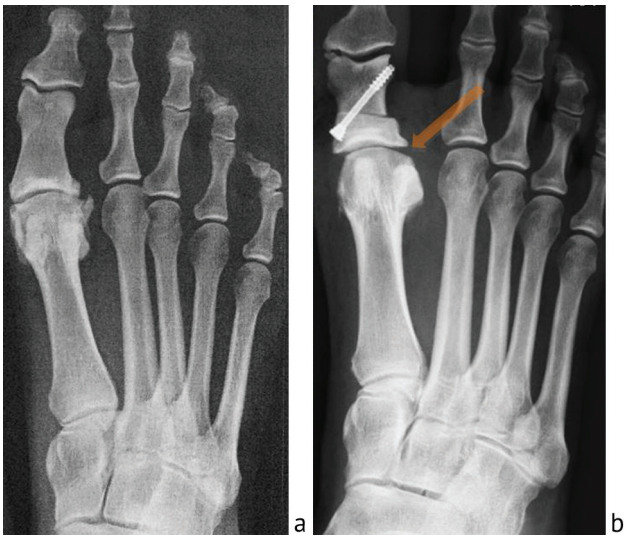

Fig. 5 Preoperative (***a***) and postoperative (***b***) weight-bearing AP radiographs of the right foot

The Chevron osteotomy of M1 (n = 3) was produced with M1P1 ⩽ 30° and M1M2 ⩽ 12°, and the scarf osteotomy (n = 5) was performed for M1M2 measuring 19–25°. Reconstructive procedures on lateral rays were added to operative interventions on the first ray. No postoperative complications were observed in the series and radiographs showed consolidation of osteotomized bone at 1.5 to 3 months postsurgery. Long-term outcomes were assessed using the American Orthopaedic Foot & Ankle Society (AOFAS) scale for the forefoot (Table 2) and the Foot and Ankle Ability Measure (FAAM) [19] with percent evaluation of major functional parameters.

Patients were also asked to assign categorical rank (excellent, good, fair, poor) in self-evaluation form because most surgeries aimed to improve quality of life without absolute medical indications for the procedures.

Table 2

Interpretation of aofas scores

Rating	Points
Excellent	95–100
Good	75–94
Fair	51–74
Poor	0–50

Statistical analysis

Statistical analysis was performed with STATISTICA 12.0 computer software, Stat Soft, Inc. The Shapiro-Wilk test was used to determine normality of distribution in the groups. The data obtained were summarized as means ± standard deviations with maximal and minimal values in normal distribution; numerical data were presented with median and interquartile range when distribution was different from the norm. Quantitative data were presented in box plots. The Wilcoxon signed-rank test was used to analyze data in two related paired samples. The Mann-Whitney U test was used to compare differences between two independent groups. For calculations, a significance level of 5 % ($p \leqslant 0.05$) was adopted.

Surgical treatment algorithm

Indications to surgical treatment of HR included failed non-operative treatment and persistent pain, high functional demands, wish to wear fashionable or high heeled shoes, practice sports activities without restrictions. Technique of cheilectomy was different from the classical procedure offered by DuVries. Medial approach was used to dissect the capsule and excise dorsal osteophytes from P1 and M1 sides with oscillating saw. Then osteophytes were excised medially and laterally followed by release of the plantar capsule and sesamoid hammock. Substantial cartilage defects were repaired with microfracture. Resection of 1/3 of the head of M1 and a part of the articular surface of P1 produced in some cases was meant to increase dorsiflexion intraoperatively to 70° and prevent bone impingement. Preoperative planning included measurement of metatarsal index and identification of hallux valgus interphalangeus that are considered by some authors as predisposing factors to HR. An increased intermetatarsal angle was an indication to osteotomy of P1 aimed at correction of P1P2 (Akin osteotomy) and reasonable decompression of the joint. In some cases, the base of the osteotomized fragment was shifted dorsally (Moberg osteotomy) to increase ROM in the first MTPJ to facilitate dorsiflexion sacrificing plantar flexion. Excessive length of M1 in comparison with that of M2, hallux valgus were indications to osteotomy of M1. Varus alignment of M1 was the key point to preoperative planning determining the amount of resection for M1 shortening and reorientation of the surface of the first MTPJ. The Chevron osteotomy was produced in the classical manner without L-shaped modification. In our opinion, modularity of the Chevron osteotomy allows for multiplanar correction with excellent reproducible outcomes and minimum complication rate. Scarf osteotomy was also performed in the classical style. Resection of cortical bone was produced with the Chevron osteotomy in all cases for M1 shortening and optimal decompression of the first MTPJ.

RESULTS

AOFAS scores showed 90% of excellent results (18 operative interventions) and 10% of fair (2 surgeries) results. Neither fair nor poor outcomes were observed. The median AOFAS score was 60.0 (interquartile range, from 49.5 to 65.5) that increased postsurgery to 97.0 (interquartile range, from 95.0 to 100.0) and was statistically significant ($p < 0.05$). Preoperative and postoperative AOFAS scores are presented in Figure 6.

Subjective patient satisfaction was rated as 'excellent' in 60 % of the cases (12 surgical interventions), 'good' in 40 % (8 interventions). Neither 'fair' nor 'poor' subjective scores were recorded. The median postoperative FAAM score on activities of daily living subscale was 100 % (interquartile range, from 100 to 100 %) and on subjective form of activities of daily living subscale was also 100% (interquartile range, from 90 to 100 %) (Fig. 7). The FAAM sports subscale was scored only in 14 cases of surgical treatment of HR. The median postoperative FAAM score on sports subscale was 97 % (interquartile range, from 93 to 100 %) and on subjective sports form was 90 % (interquartile range, from 80 to 100 %) (Fig. 8).

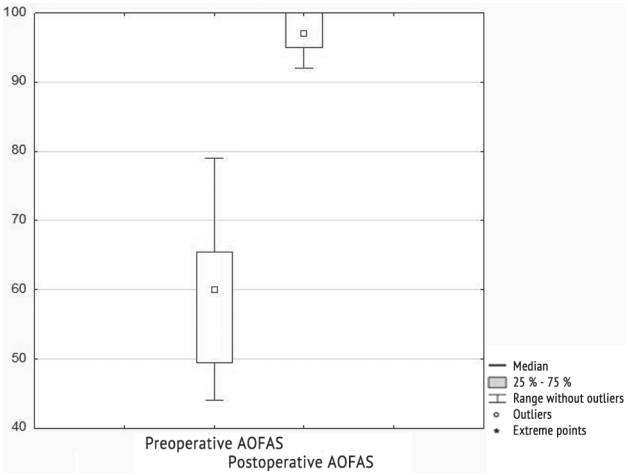

Fig. 6 Preoperative and postoperative AOFAS scores

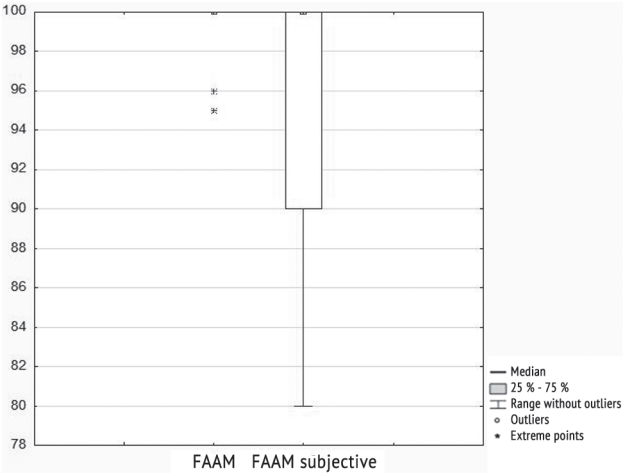

Fig. 7 FAAM scores on ADL subscale

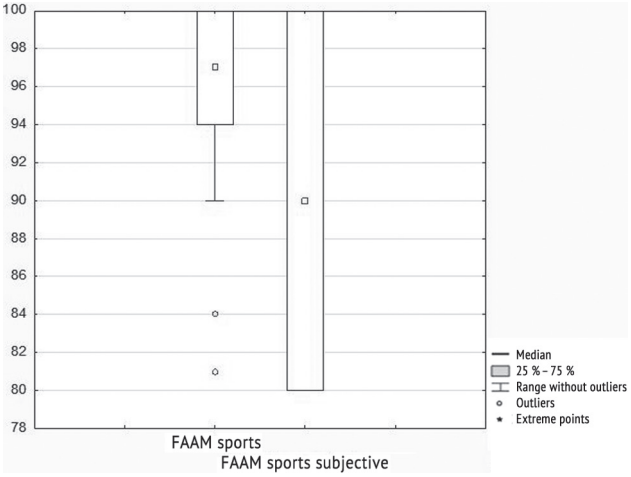

Fig. 8 FAAM scores on sports subscale

Several parameters that were considered to be important for the functional prognosis of surgical treatment of HR were included in the study. Those were VAS scores and ROM in the first MTPJ. The median VAS score was 5 points (interquartile range, from 4 to 5) preoperatively and improved to 1 point postoperatively (interquartile range, from 0 to 1) that was statistically significant ($p < 0.05$) (Fig. 9).

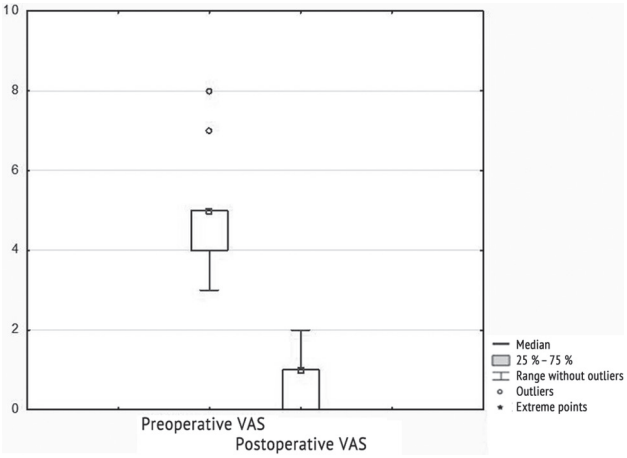

Fig. 9 Preoperative and postoperative VAS scores

Clinical measurements of ROM in the first MTPJ showed statistically significant increase in the median dorsiflexion from 10° (interquartile range, from 5° to 10°) preoperatively to 40° (interquartile range, from 40° to 50°) postoperatively ($p < 0.05$) (Fig. 10) with ROM maximally increased by 45° observed in cheilectomy and osteotomy of M1.

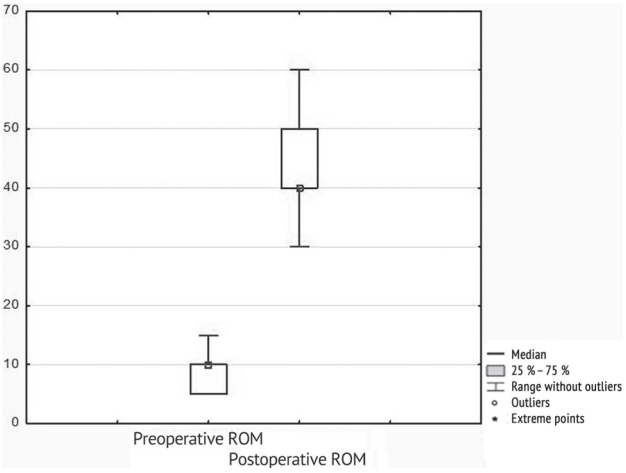

Fig. 10 Preoperative and postoperative dorsiflexion in the first MTPJ

DISCUSSION

Cheilectomy has been reported to relieve pain and increase ROM in the first MTPJ in early stages of HR. Choosing the appropriate treatment strategy for advanced first MTPJ arthritis in younger and active patients is dependent upon many factors. Although some studies show higher efficacy of combined operations (cheilectomy and osteotomy of P1) as compared to standalone cheilectomy there is no analysis of outcomes with regard to stages of the disease and no surgical treatment algorithm offered. O'Malley *et al*. reviewed 81 patients with advanced HR classified as Hattrup and Johnson Grade III who

underwent a cheilectomy and extension osteotomy of P1.The mean duration of follow-up was 4.3 years. The average AOFAS scores improved significantly from 67.2 points preoperatively to 88.7 points postoperatively; 69 (85.2 %) patients were satisfied with the results of treatment and 4 (4.9 %) subsequently underwent arthrodesis to treat persistent symptoms at the first MTPJ [20]. Jones and Sweet compared the long-term outcomes of cheilectomy, decompressive osteotomy and arthrodesis in a retrospective review of 80 patients (95 feet) undergoing surgical treatment for HR.The decompressive osteotomy group had the highest return-to-duty rate, satisfaction rate, and Maryland Foot Scores (MFS) of all three surgical groups, although these differences were not statistically significant [21]. Waizy *et al*. compared the outcomes of 23 patients with HR graded as Regnauld 1–2 treated with standalone cheilectomy and 23 patients with HR graded as Regnauld 1-3 treated with cheilectomy and Kessel-Bonney osteotomy of the proximal phalanx. The mean dorsiflexion increased to 24.8° in group I patients and to 20.8° in group II patients. Positive results were obtained in 85% of grade I HR patients and in 63% of grade II HR [16].

Cheilectomy is normally recommended as the operative standard of care for Coughlin and Shurnas grades 1-2 HR and some cases of grade 3 HR. We offered to extend indications to the procedure by adding osteotomy of M1 and/or P1 to provide greater decompression at the first MTPJ. The outcomes of our series appeared to be better as compared to those reported in the literature.

From our experience, the surgical procedure should aim to address bone impingement in the joint providing adequate pain relief rather than focus on achieving greater ROM in the first MTPJ. The approach can be applied for all patients with grade 3 HR irrespective of the extent of cartilage damage. In our opinion, positive outcome of surgical intervention is explicitly associated with postoperative rehabilitation strategy with the focus on early passive manual mobilization of first MTPJ with the safety ensured. Supervision is to be arranged for the patient performing manipulations to regain ROM and prevent contractures and adhesions in the operated joints. Variations in the results of treatment measured with different scoring systems are thought to be caused by the absence of adequate objectivization of outcomes. The high median AOFAS score measured in our series being similar to that reported by Coughlin and Shurnas can be explained by specific features of the questionnaire: all patients reported their level of pain as 'no pain or mild occasional with no activity limitations' that can be explicable even in presence of minimum pain. The AOFAS score was low only in the function category in our series: patients reported limited sports activity and limited ROM in the first MTPJ. Some differences in AOFAS scores and subjective satisfaction can be explained by disparities in patient's expectations and outcomes of surgical treatment. 'Excellent' result on AOFAS scale can be different from 'good' for the patient simply as limited sports activity or inability to use fashionable conventional shoes. FAAM subjective form is deemed to provide more objective assessment of functional mobility having sports subscale in addition to activities of daily living subscale. A limitation of the study is the small sample size due to our intention to provide more accurate findings excluding the patients who failed to attend at least one follow-up visit. Despite the small number of surgeries performed we could identify the differences between the groups using nonparametric Wilcoxon signed-rank test (up to 25 elements) with distribution of values tend to be normal with greater number of observations. Another limitation of the study is the absence of control group and further investigation of long-term follow-ups is required.

CONCLUSION

Cheilectomy as a standalone procedure or in conjunction with P1 osteotomy and/or M1 osteotomy has demonstrated 100% positive long-term outcomes for patients with Coughlin and Shurnas grade-3 HR. The procedure can be advocated as a predictable and excellent option for this grade HR. First MTPJ decompression is to be considered with P1 osteotomy and/or M1 osteotomy for grade-3 HR patients in preoperative planning to ensure normal forefoot anatomy. Cheilectomy offers the advantages of being joint sparing, preserving joint motion as compared to arthrodesis of the first MTPJ and can be an option for some cases of Coughlin and Shurnas grade-3 HR.

***Conflict of interests**: not declared.*

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