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Original Article

Evaluation of the clinical-radiographic results of patients undergoing arthroscopic metatarsal-phalangeal arthrodesis of the hallux

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Abstract

Objective: To present the clinical and radiographic results of patients undergoing arthroscopic metatarsal-phalangeal arthrodesis of the hallux, depict the technique and report complications.

Methods: This study involves a series of 9 patients (10 feet), all with advanced hallux rigidus (Coughlin-Shurnas grades 3 and 4). All patients underwent an arthroscopic procedure through two dorsal portals with small-joint instruments. Outcomes were assessed using the AOFAS functional score and a visual analogue scale of pain. The radiographic parameters of interest were metatarsal-phalangeal angulation in the anteroposterior (pre- and postoperative) and lateral (post-operative) views, as well as ray shortening.

Conclusion: Arthroscopic metatarsal-phalangeal arthrodesis is an excellent treatment option in advanced stages of hallux rigidus, with minimal disruption, excellent outcomes, and a low incidence of complications.

Level of Evidence IV; Therapeutic Studies; Case Series.

Keywords: Arthrodesis; Metatarsalphalangeal joint; Hallux; Arthrosis.

Introduction

Hallux rigidus (HR) is a degenerative disease that affects the first metatarsal-phalangeal joint (1st MTP), characterized by pain and progressive loss of movement in this joint. It was first described by Davies-Colley[1] in 1887 using the term hallux flexus, with "hallux rigidus" later coined by Cotterill[2]. HR represents the second most common pathological condition in this joint. It is a cause of important functional impairment, especially for women, who eventually develop great restriction to the use of high-heeled shoes. The main radiographic changes are reduced joint space, dorsal osteophyte formation, and development of sclerosis/cysts. This condition most commonly affects women, and is initially unilateral, but 80% of the patients develop a contralateral lesion within 9 years[3].

The cause of the disease is not fully understood, but it seems to be related to factors such as trauma, osteochondral injuries, rheumatic diseases, and anatomical issues, such as the shape of the head of the first metatarsal bone and the length of this bone. The Coughlin and Shurnas[4] classification is the one most used today, based on clinical and radiographic criteria, which include changes in joint space reduction, osteophyte formation, intensity of symptoms, and range of motion of the 1st MTP. Coughlin-Shurnas grades 3 and 4 represent advanced disease and almost always translate into major functional impairment.

There are numerous treatment options, including analgesics, modifications and adaptations to shoes, physical therapy, joint injections, and surgical treatment. Surgery is usually per-

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formed when conservative treatment fails, but it may be the first option in advanced conditions.

The main procedures described for advanced stages of HR are arthrodesis and interposition arthroplasty[5], but osteotomies have also been described[6,7]. Metatarsal-phalangeal arthrodesis is a safe approach that provides a high level of patient satisfaction, with marked improvement in pain and gait quality.

The gold standard for the treatment of the final stages of HR is arthrodesis of the 1st MTP, which can be performed through an open, minimally invasive[8] or arthroscopic approach. Lui reported good outcomes in the treatment with arthroscopic arthrodesis in cases of severe hallux valgus[9] and in hallux varus[10].

In this study, we report the clinical and radiographic results of arthroscopic metatarsal-phalangeal arthrodesis in the treatment of advanced RH.

Methods

This study was approved by the Ethics Committee on 05/17/2021 and started the following week, with the provision of an informed consent form and application of postoperative functional scores.

A consecutive series of nine patients (seven women and two men, 10 feet), with a mean age of 61.2 years (range 54 to 69 years, SD 4.49) underwent metatarsal-phalangeal arthrodesis of the hallux for the treatment of advanced HR (Coughlin-Shurnas grades 3 and 4) from November 2016 to October 2020. The mean duration of follow-up was 27.8 months (7 to 54 months, SD 16.97). The average time from first visit to surgery was 25 days. All the patients were operated on by the senior surgeon.

HR was diagnosed after clinical and radiographic evaluation, including pre- and postoperative radiographs in anteroposterior and lateral views, under load. The 1st MTP joint alignment angle was measured in AP (pre- and postoperative) and lateral (postoperative only) views. The length of the first ray was measured by tracing the first metatarsal center-base in the joint with the cuneiform to the midpoint of the joint line of the proximal phalanx in the interphalangeal joint, on pre- and postoperative radiographs (Figure 1). Thus, we sought to assess the postoperative shortening created by the arthrodesis.

All patients were evaluated by the AOFAS functional score[11] and by a visual analogue scale of pain before and after surgery.

The patients were all ambulatory in the community, and did not depend on external aids for walking. No patient had undergone previous surgery on the forefoot; one patient had a history of a malignant calcaneal tumor being resected during childhood. One patient was diabetic, two were smokers (10 cigarettes/day), and two were hypertensive.

Surgical technique

The surgical procedure was performed in the supine position, under spinal anesthesia. We placed an Esmarch band in the middle third of the leg and administered antibiotic pro-

Figure 1. Method for measuring the length of the first ray on anteroposterior radiography, under load.

Figure 2. Portal placements and their relationship with the extensor hallucis longus tendon and medial dorsal cutaneous nerve.

phylaxis 20 minutes before exsanguination. The foot was placed at the edge of the surgical table for better access.

We created two classic 5-mm dorsomedial and dorsolateral portals, placed 5 to 7 mm medial and lateral to the extensor hallucis longus tendon (Figure 2), respectively. Under manual finger traction, we introduced a curved hemostat through the portals to make room for the video instruments. After properly opening the joint, we entered with the optics and shaver. We used 2.7-mm instruments (30-degree optics, bone shaver, and synovial shaver).

The endoscope was positioned on the medial portal and the shaver on the lateral one, enabling us to identify the joint surfaces of the metatarsal head and the base of the proximal phalanx. The procedure was continued with bone head decortication of the three central zones and three lateral zones of the head, as well as of the corresponding region of the phalanx, using a 2.7 round bur (Figure 3). We then inverted the instruments' position, placing the shaver through the medial portal, and performed the same procedure in the medial areas. Manual traction was done only when introducing the instruments.

After joint-surface decortication, we fixed the arthrodesis in 9 of the 10 feet with two 4.5-mm cannulated steel screws (AMGS, Belo Horizonte, Brazil) in a crisscross setup. In one patient, we used a single 4.5-mm cannulated screw and 1.5-mm Kirschner wire instead. In all cases, fixation was guided by fluoroscopy. The first screw was passed obliquely from the medial proximal part of the metatarsal head (immediately proximal to the bunion) to the lateral part of the proximal phalanx. The second screw was passed after initial drilling from the base of the proximal phalanx (10 to 12 mm from the articular surface) to the lateral area of the first metatarsal. The initial perforation and fixation were performed by keeping the proximal phalanx at 10 to 15 degrees in dorsiflexion in relation to the ground, while trying to maintain an alignment of 10 to 15 degrees with the axis of the first metatarsal (Figures 4 A, B and C).

Once the arthrodesis fixation was completed, we sutured the wounds with 3-0 nylon and applied a sterile dressing, without any external fixation. All patients were discharged from hospital the next day, with a prescription to wear Barouk shoes for support for 6 weeks. The stitches were removed at 15 to 20 days, and control radiographs were obtained at 6 and 10 weeks. Most patients started physical therapy within 6 weeks, requiring 15 to 30 sessions for complete recovery.

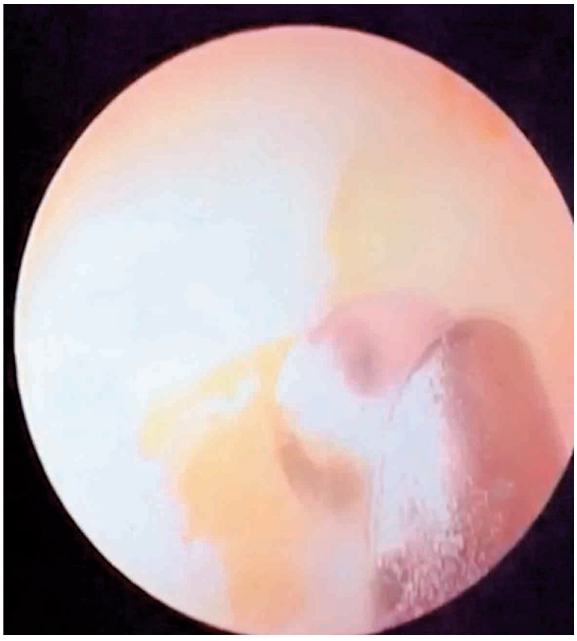

Figure 3. Decortication of the first metatarsal head with a bone shaver.

Figure 4. Preoperative (A), 10-week postoperative (B), and late postoperative (C) radiographs.

Statistical analysis

Initially, we ran an exploratory analysis to establish data normality, using the Shapiro-Wilk test, ideal for the number of samples in our study. We also performed an outlier detection test in GraphPad QuickCalcs Outlier Calculator software.

Considering the parametric nature of the data (normal distribution), we obtained the mean, standard deviation, and minimum and maximum values for each variable analyzed; we also obtained the absolute frequency (n) and percentage (%) values for descriptive analyses.

We used the paired Student's t-test for comparative analysis between the preoperative and postoperative periods. For all analyses performed, the differences obtained were considered statistically significant when the p-value was less than 0.05 ($p<0.05$).

We used GraphPad Prism® version 5.0 for Windows and Stata® version 14.0 software for the statistical analyses.

Results

On postoperative clinical-radiographic follow-up of our nine patients (10 feet), eight feet showed a healed arthrodesis with radiographic control within 6 weeks. The other two feet showed no more than 50% healing of the articular surface at this time, but within 10 weeks of surgery both showed clear radiographic healing.

All patients had improvement of pain within 6 weeks, sustained at later visits. Two patients had sensory changes in the area of the medial dorsal cutaneous nerve, with recovery 4 months after the surgical procedure. One patient developed pain in the central region of the forefoot, improving with transient adaptation to footwear. No patient had superficial or deep infection upon follow-up, nor were there any systemic complications such as fever or thromboembolic events.

Statistical analysis of the data shown in table 1 revealed no shortening of the first ray after arthrodesis. There was a reduction and relative correction of the metatarsal-phalangeal angle in anteroposterior radiographs after the procedure (Table 2).

The results were evaluated comparing the pre- and postoperative functional score using the AOFAS score and the visual analogue scale of pain (Table 3).

Statistical analysis showed significant improvement in functional scores and in AOFAS score analysis (Tables 3 and 4).

Discussion

The main findings of this study are the effectiveness of the arthroscopic technique to achieve arthrodesis healing, the low morbidity of the procedure, and its success when considering the clinical outcome of pain and gait quality improvement. All patients showed significant clinical improvement at 10-week follow-up.

Arthroscopic procedures are less aggressive, with consequent preservation of periarticular vascularization, enabling the healing process to occur more quickly and with a shorter recovery period, as already shown in studies for other joints of the foot[12] and ankle[13].

Forefoot endoscopic and arthroscopic procedures have been performed for almost 40 years[14] and, in the last 15 years, have been developed to perform or assist in the treatment of various pathological conditions, such as hallux valgus[9], hallux varus[10], osteochondral lesions of the 1st MTP[15], and arthrodesis. Successive studies have shown safety and success in approaching these different lesions of the metatarsal-phalangeal joint of the hallux.

A cadaver study showed that the arthroscopic procedure was able to decorticate an area greater than 90% of the joint surface of both the metatarsal head and the base of the proximal phalanx, with an average shortening of 2.2 mm in the first ray[16].

In our study, we confirmed that the arthroscopic procedure does not shorten the first ray (88.5 mm –87.7 mm, $p=0.15$). In four of the ten feet we studied, there was instead lengthening

Table 1. Pre- and postoperative general clinical and radiographic data

Patient	Report	Sex	Age	Follow-up (months)	Fixation technique	Preop AP MTP angle	Postop AP MTP angle	Postop lateral MTP angle	Preop length (mm)	Postop length (mm)
1	E	F	60	50	2 screws	15	15	29	87.9	84.4
2	D	F	62	54	2 screws	13	5	27	84.4	82.6
3	D	F	62	41	1 screw + 1 K-wire	10	13	25	82.8	81.9
4	D	F	58	29	2 screws	16	18	31	87.8	85.7
5	D	M	61	34	2 screws	16	12	29	92.8	94.4
6	E	F	65	26	2 screws	19	13	27	90.5	89
6	D	F	65	16	2 screws	26	20	25	88.9	89.7
7	D	M	69	14	2 screws	19	7	29	101.6	102.1
8	D	F	54	7	2 screws	20	18	28	81.7	82.1
9	E	F	56	7	2 screws	26	21	23	86.8	85.5

Table 2. Pre- and postoperative measurements of metatarsal-phalangeal length, anteroposterior (AP) angle, and lateral angle in patients with metatarsal-phalangeal arthrodesis of the hallux

	Mean (± SD)	Min-Max	p-value
Length (mm)			
Preop	88.52 (± 5.71)	81.70 – 101.60	0.1505
Postop	87.74 (± 6.40)	81.90 - 102.10	
MTP AP angle			
Preop	18.00° (± 5.16)	10 - 26	0.0292*
Postop	14.20° (± 5.31)	5 - 21	
MTP side angle			
Postop	27.30° (± 2.41)	23 - 31	-

SD= standard deviation.
AP= anteroposterior angle.
MTP= metatarsal-phalangeal joint.
* Statistically significant according to the paired Student's t test (p<0.05).

Table 3. Pre- and postoperative AOFAS functional scores and visual analogue scale of pain

Patient	Preop AOFAS score	Postop AOFAS score	Preop VAS	Postop VAS
1	39	85	10	0
2	28	85	10	0
3	49	70	7	3
4	39	87	10	0
5	52	87	8	0
6	47	90	9	0
6	47	90	10	0
7	49	90	6	0
8	45	90	8	0
9	49	80	10	3

Table 4. General and stratified assessment of AOFAS score for the forefoot obtained from patients with metatarsal-phalangeal arthrodesis of the hallux, in the pre- and postoperative periods

	Mean (± SD)	Min-Max	p-value
General AOFAS score			
Preop	44.40 (± 7.17)	28 - 52	<0.0001*
Postop	85.40 (± 6.29)	70 - 90	

of the ray, probably as a result of correcting the preoperative valgus. This condition was reflected in the clinical findings, in which only one patient had transient transfer metatarsalgia, which resolved after 6 months. The procedure also reduced or corrected the 1st MTP valgus in six of seven patients with an angle greater than 15 degrees.

Arthroscopic arthrodesis of the 1st MTP provided an improvement in AOFAS functional score (44.4 – 85.4, p<0.0001), and all patients improved in their functional condition for activities of daily living when compared to their preoperative baseline.

For several reasons, arthroscopic arthrodesis seems to be a very attractive treatment option. Low aggressiveness, minimal postoperative pain, quick recovery, fair cosmetic appearance of the scars and the ability to resolve pain and function issues encourages us to apply this technique in future cases. We know that video-assisted surgery requires skill and experience, which are developed over time and with practice in larger joints over the years. The instruments are delicate and require care in handling.

The present study has some limitations. First, the small number of patients precludes more solid conclusions about the procedure. Second, we did not run a gait analysis comparing forefoot biomechanics before and after surgery. Such an analysis would certainly provide important data regarding the reestablishment or improvement of load distribution in the metatarsal heads and in gait pattern. A larger number of patients and longer follow-up would be important to confirm the positive preliminary findings of our study.

Conclusions

Arthroscopic metatarsal-phalangeal arthrodesis is an excellent treatment option for advanced stages of hallux rigidus, with minimal invasiveness and excellent outcomes, in addition to a low incidence of complications.

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