

Original Article

Evaluation of range of motion of hallux metatarsophalangeal and interphalangeal joints after periarticular osteotomies

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Abstract

Objective: Evaluate the impact of Chevron and extended Chevron techniques associated with Akin osteotomy on the range of motion (ROM) of hallux metatarsophalangeal joint (MPJ) and interphalangeal joint (IPJ) after three months and one year.

Methods: Sixteen patients (17 feet) were evaluated for the ROM of hallux MPJ and IPJ pre-and postoperatively, the flexion-extension measurements were performed using a goniometer.

Results: Comparing the pre-and postoperative measurements at three months and one year, the ROM decreased in MPJ extension and flexion, 9° and 5°, respectively, and IPJ flexion, 5°. The values presented statistical significance according to the analysis demonstrated ($p > 0.05$). However, the decrease in IPJ extension was not statistically significant (decrease of 0.8° and $p < 0.05$).

Conclusions: Periarticular osteotomies of hallux MPJ had a significant decrease in the ROM after three months and one year.

Level of Evidence II; Therapeutic Studies - Investigating the Results of Treatment; Prospective Comparative Study.

Keywords: Hallux valgus; Range of motion, articular; Metatarsophalangeal joint.

Introduction

Hallux valgus affects 2-4% of the general population, especially between 18 and 65 years⁽¹⁾, mainly in women after the 5th decade of life, and the majority are bilateral⁽²⁾. It has intrinsic and extrinsic causes and can generate pain, progressive aesthetic deformity, and functional deficit⁽³⁾.

Surgical indication depends mainly on functional deficit and pain. Several techniques can be used depending on the classification, which is graded according to the Coughlin and Shurnas classification^(2,3). This classification is based on the measurements of the hallux valgus angle (HAV) and intermetatarsal angle (IMA) associated with a sesamoid dislocation, and is divided into mild, moderate, and severe⁽³⁾.

Other factors to be considered are arthrosis and unity in the first metatarsophalangeal joint (MPJ), the mobility of the metatarsal joint, and the patient's age. These factors are fundamental for surgical decisions⁽³⁾.

In general, surgical techniques with a more distal approach and diaphyseal techniques in the first metatarsal are more indicated for moderate hallux valgus and proximal approaches for severe hallux valgus⁽⁴⁾.

As proposed in this study, the Chevron technique is more indicated for mild hallux valgus, while extended Chevron osteotomy is more indicated for moderate hallux valgus. Akin osteotomy is mainly indicated for interphalangeal hallux valgus with joint congruence. It also helps reduce hallux pronation and shorten long proximal phalanges. It can be associated with any other osteotomy to improve aesthetic results^(2,3).

However, these surgical procedures for correcting hallux valgus are not complications-free. One of the most common complications is MPJ stiffness⁽⁵⁾, which may limit physical activities and require revision surgery⁽⁶⁾. In addition, the loss of range of motion (ROM) implies gait, especially the inefficiency observed in the propulsion phase^(7,8).

Study performed at the Hospital de Base, Faculdade de Medicina de São José do Rio Preto, São José do Rio Preto, SP, Brazil.

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The objective of this study is to evaluate the impact of Chevron and extended Chevron techniques associated with Akin osteotomy on ROM of hallux MPJ and interphalangeal joint (IPJ) after three months and one year.

Methods

The study was conducted from January 2019 to December 2019, and 16 patients (17 feet) were evaluated, 15 female and one male, with a mean of 57.8 years (range 33-70). The study was approved by the institution's ethics committee.

The MPJ and IPJ were evaluated and measured using a goniometer before, at three months, and one year after surgery. The measurements of the MPJ were performed with one hand immobilizing the first metatarsal head and the other mobilizing the proximal phalanx. The measurements on the IPJ were performed with one hand immobilizing the proximal phalanx and the other hand mobilizing the distal phalanx.

The patients had no deformities in the smaller toes, and the surgeries selected were the only ones performed. In addition, none of the patients underwent surgery due to recurrence of hallux valgus or had radiographic signs of MPJ arthrosis.

In nine feet, Chevron + Akin osteotomies were performed; in eight feet, extended Chevron + Akin osteotomies. The attending physician evaluated the patient during the pre-and postoperative and participated in all surgical procedures.

Table 1 shows the patient's demographic data.

Surgical Technique

The patient was in decubitus position under spinal anesthesia, and a tourniquet was placed on the thigh. First, medial incision and careful dissection were performed for capsulotomy and resection of the medial eminence using a

saw for small bones. Then, the Chevron or extended Chevron osteotomies were performed in a V-shape with a saw for small bones, with an apex starting around 8-10 mm from the articular surface, approximately in the center of the metatarsal head.

In Chevron osteotomy, its arms form a 60° angle to each other and target the dorsal and plantar cortical of the first metatarsal, from head center to proximal. In the extended Chevron, the arm is similar to the Chevron, and the extended cut is located dorsally in the first metatarsal, stretching to the proximal metaphyseal region, forming 30° of angulation with the plantar arm.

In our hospital, fixation is performed with a conical cannulated screw in Chevron osteotomy and two screws in extended Chevron. Regularization of the osteotomy edge was performed, followed by tension-free capsulorrhaphy and subcutaneous suture with absorbable wire and skin suture.

For the Akin osteotomy, a medial incision was made in the hallux, mid-diaphyseal osteotomy in the hallux proximal phalanx using a saw for small bones, leaving the lateral cortex intact and closing the medial wedge. The fixation was performed with a conical cannulated screw, proximal to distal and medial to lateral.

The postoperative performed in our institution is based on immobilization with gauze forming a "double H" between the hallux and the second toe. The patient was instructed to perform MPJ and IPJ extension and flexion early and immediate load with rigid postoperative shoes and no load in the forefoot. The dressing is changed every seven days, and the stitches were removed after three weeks. Patients were instructed to intensify the ROM exercises and were referred to physiotherapy at this time. The use of shoes was maintained for six to eight weeks when the patient was instructed to wear common shoes.

Table 1. Demographic data of the patients evaluated in the study.

Patient	Sex	Age	Side	Surgery date	Surgery performed
1	Female	70	Right	03/10/2019	C + A
2	Female	59	Left	03/25/2019	EC + A
3	Female	47	Right	04/11/2019	EC + A
4	Female	58	Right	04/17/2019	C + A
5	Female	64	Left	06/03/2019	C + A
6	Female	70	Left	06/10/2019	C + A
7	Female	78	Right	06/06/2019	C + A
8	Female	65	Right	06/12/2019	C + A
9	Female	46	Left	06/12/2019	EC + A
10	Female	44	Left	07/10/2019	EC + A
11	Female	60	Left	07/15/2019	EC + A
12	Female	33	Bilateral	08/07/2019	EC + A Bilateral
13	Male	52	Right	09/02/2019	EC + A
14	Female	66	Right	08/12/2019	C + A
15	Female	53	Right	10/10/2019	C + A
16	Female	60	Right	10/11/2019	C + A

C: Chevron ; EC: Extended Chevron; A: Akin

Results

Table 2 shows the pre-and postoperative ROM measurements.

Statistical analysis

The data was collected using Microsoft Excel® (Microsoft Corporation, Redmond, Washington, USA).

Descriptive statistical analysis was performed based on central tendency, dispersion, and frequency measures.

For the inferential statistical analysis of the quantitative variables, the Kolmogorov-Smirnov test was used to verify the data normality, and then the paired t-test and ANOVA test with repeated measures were applied.

In all analyses, $p < 0.05$ and a test power of 80% were considered statistically significant.

Measures for MPJ flexion and extension and IPJ flexion were considered statistically significant ($p < 0.05$). Thus, as the study is statistically significant, the decrease in hallux ROM is representative. Table 3 shows pre-and postoperative mean ROM. Tables 4 and 5 show the pre-and postoperative mean ROM of Chevron + Akin and extended Chevron + Akin, respectively.

Discussion

There are several surgical techniques for correcting hallux valgus, depending on the severity and associated factors, such as arthrosis, but these techniques are not complications-free.

The most frequent surgical complications are rotational hallux deviation, pseudarthrosis, decreased ROM, infection, dehiscence and/or necrosis of the surgical wound, neurological lesion⁽⁶⁾, hallux varus, avascular necrosis of the first metatarsal head⁽⁷⁾, recurrence of hallux valgus, and implant failure⁽⁹⁾. In addition, in the literature, there are reports of stiffness between 7% and 38% of patients after surgery⁽¹⁰⁾.

The ROM decrease of hallux MPJ and IPJ is one of the most common complications⁽⁵⁾. Some authors have demonstrated in their studies that the ROM decrease, especially the MPJ, leads to the reduction of the ankle plantar flexion during the gait, generating an inefficient propulsion movement^(7,8), considering that it is necessary dorsiflexion between 40° and 60° of the first MPJ for the propulsion to occur properly⁽¹¹⁾. In our study, the MPJ extension maintained a mean of 55° after one year of surgery.

In addition, adequate MPJ dorsiflexion is essential during the terminal phase of gait support and in the pre-swing phase

Table 2. Pre-and postoperative ROM measurements

Patient	Pre ROM MPJ	Pre ROM IPJ	Post ROM MPJ	Post ROM IPJ	MPJ ROM 1 year	IPJ ROM 1 year
1	E60 F55	E0 F40	E50 F55	E0 F40	E50 F55	E0 F35
2	E70 F20	E0 F75	E60 F15	E0 F65	E55 F10	E0 F70
3	E50 F50	E0 F50	E40 F45	E0 F40	E45 F50	E0 F50
4	E80 F50	E0 F50	E65 F50	E0 F40	E70 F45	E0 F50
5	E60 F40	E10 F70	E50 F50	E10 F70	E55 F40	E5 F60
6	E50 F50	E5 F60	E45 F45	E0 F55	E50 F40	E0 F50
7	E70 F50	E0 F65	E50 F50	E0 F60	E55 F45	E0 F60
8	E40 F40	E5 F60	E40 F40	E5 F55	E40 F40	E0 F60
9	E60 F55	E5 F60	E50 F55	E5 F55	E60 F55	E5 F60
10	E50 F50	E0 F50	E45 F45	E0 F45	E45 F40	E0 F45
11	E80 F60	E0 F70	E65 F50	E0 F60	E65 F45	E0 F60
12	E90 F70	E0 F70	E65 F50	E0 F65	E75 F60	E0 F70
12	E90 F70	E0 F70	E65 F50	E0 F65	E75 F60	E0 F65
13	E50 F50	E0 F70	E40 F45	E0 F70	E40 F45	E0 F60
14	E60 F60	E0 F60	E50 F50	E0 F60	E55 F55	E0 F60
15	E70 F50	E0 F65	E65 F50	E0 F65	E60 F50	E0 F60
16	E70 F75	E5 F80	E50 F60	E0 F75	E50 F75	E5 F70

ROM: range of motion; MPJ: Metatarsophalangeal joint; IPJ: Interphalangeal joint; E: extension; F: flexion.

Table 3. Pre-and postoperative mean ROM

	Mean preop	Mean postop – 3 months	Mean postop – 1 year
MPJ extension	64.7°	52.64°	55.58°
MPJ flexion	52.64°	47.35°	47.64°
IPJ extension	1.76°	1.17°	0.88°
IPJ tension	62.64°	57.94°	57.94°

MPJ: Metatarsophalangeal joint; IPJ: Interphalangeal joint.

to allow a smooth progression of the foot body⁽⁷⁾. Without the ideal amplitude, the gait presents reduced step length, shorter duration of the support phase, and decreased ankle plantar flexion at the tip of the foot^(7,8). There is also a delay in the calcaneus detachment and a displacement of the reaction forces to the ground before the first MPJ on the side of lower ROM⁽¹²⁾.

It has been demonstrated that the Achilles-calcaneal-plantar system and the medial wedge are responsible for optimizing the support of the first MPJ so that there is adequate support of the foot during the third phase of the gait swing. Failure in plantar flexion of the first MPJ, which is accompanied by traction stress of the plantar fascia, limits the hallux dorsiflexion in the transition from the second to the third phase of gait balance⁽¹³⁾.

The hallux MPJ dorsiflexion limitation often causes hyperextension of the hallux IPJ as a compensatory mechanism to avoid trauma of the distal phalanx against the ground, generating long-term arthrosis⁽¹²⁾. In a foot without changes, the hallux IPJ extension plays a role in the survey the calcaneus of the ground during propulsion⁽¹²⁾. Thus, the IPJ stiffness due to the decrease in MPJ dorsiflexion also contributes to the gait alteration.

On the other hand, some studies demonstrate that the ROM decrease of hallux MPJ and IPJ after arthrodesis did not significantly influence physical activities. For example, in the study by da Cunha et al.⁽¹⁴⁾ in 2019, most patients submitted to arthrodesis of the first MPJ presented a satisfactory return to daily and sports activities, with approximately 16% of the patients showing restriction to gait and physical activities⁽¹⁴⁾.

The study concluded that there was an objective ROM decrease hallux MPJ and IPJ after the analyzed techniques (Chevron and extended Chevron). According to the literature, this factor can be attributed to the surgical procedure or the postoperative period. The patients were instructed to perform early ROM to prevent stiffness. Despite this factor, most patients did not show ROM improvement after rehabilitation.

The literature highlighted that some intrinsic factors to the procedure might also alter the ROM of the first MPJ, such as hallux realignment, medial capsule repair, postoperative infection, and late rehabilitation⁽¹⁵⁾. In our procedures, medial capsulorrhaphy was performed without tension, and no postoperative infection was observed.

When evaluating each group separately, the patients submitted to the Chevron + Akin osteotomies presented a mean final MPJ ROM (after one year) higher than the group of

Table 4. Pre-and postoperative mean ROM in the Chevron + Akin osteotomies

Chevron + Akin	Mean preop	Mean postop – 1 year
MPJ extension	62°	53.8°
MPJ flexion	47°	49.4°
IPJ extension	2.7°	1.1°
IPJ tension	61°	56°

MPJ: Metatarsophalangeal joint; IPJ: Interphalangeal joint.

Table 5. Pre-and postoperative mean ROM in the extended Chevron + Akin osteotomies

Extended Chevron + Akin	Mean preop	Mean postop – 1 year
MPJ extension	67.5°	57°
MPJ flexion	53°	45°
IPJ extension	0.6°	0.6°
IPJ tension	64°	60°

MPJ: Metatarsophalangeal joint; IPJ: Interphalangeal joint.

extended Chevron + Akin; however, the same postoperative protocol was performed (Tables 4 and 5). The final IPJ ROM was similar in both groups. Thus, the ROM limitation can be attributed to the adherence generated in the healing process, which is worse in procedures requiring greater soft tissue dissection. In the study by Lee et al.⁽¹⁶⁾, published in 2019, patients submitted to Chevron presented a more significant ROM decrease of hallux MPJ when osteotomies were associated with a soft tissue procedure⁽¹⁶⁾.

The small number of cases in the study is a possible limitation. In addition, in our study, we preferred to make the measurement more accurate, specifying in degrees the postoperative limitation, and the function after surgery was not evaluated.

Conclusion

The surgical techniques used in this study (Chevron/ Chevron Extended associated with akin) decreased ROM of hallux MPJ and IPJ as a complication in most patients. This was evidenced by the values obtained in the study and the statistical significance achieved.

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