Modified Mitchell's Osteotomy for the Treatment of Hallux Valgus Rigidus. Description of the Surgical Technique and Medium-term Functional Evaluation

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ABSTRACT

Objective: To describe the modified Mitchell's surgical technique for the treatment of grade II hallux valgus rigidus, and to evaluate medium-term outcomes. **Materials and Methods:** Prospective observational study. Between August 2015 and January 2019, 21 patients (23 feet) with grade II hallux valgus rigidus were treated. All underwent a modified Mitchell's osteotomy. **Results:** The results are reported based on age, gender, postoperative follow-up, AOFAS score, affected foot, loss of reduction, metatarsal head collapse, residual pain, and whether the patient needed insoles to be discharged. The AOFAS score at 18 months was 94.78. On average, the patients returned to work after 16.6 days and to their usual activities after 3.43 months. **Conclusion:** We present a surgical technique that combines the benefits of the Chevron and Mitchell osteotomy, with excellent functional clinical outcomes.

Keywords: hallux valgus rigidus, Mitchell's osteotomy
Level of Evidence: IV

Tratamiento del hallux valgus rigidus con osteotomía tipo Mitchell modificada. Descripción de la técnica quirúrgica y evaluación funcional a mediano plazo

RESUMEN

Objetivo: Describir la técnica quirúrgica de Mitchell modificada para el tratamiento del hallux valgus rigidus grado 2, y evaluar los resultados a mediano plazo. **Materiales y Métodos:** Estudio prospectivo observacional. Entre agosto de 2015 y enero de 2019, 21 pacientes (23 pies) con hallux valgus rigidus grado 2 fueron sometidos a una osteotomía tipo Mitchell modificada. **Resultados:** Se comunican los resultados sobre la base a la edad, el sexo, el seguimiento posoperatorio, el puntaje de la AOFAS, el pie afectado, la pérdida de reducción, el colapso de la cabeza del metatarsiano, el dolor residual y la necesidad de plantillado para el alta. El puntaje de la AOFAS a los 18 meses fue de 94,78. Los pacientes retornaron a su actividad laboral fue, en promedio, a los 16.6 días y a sus actividades previas, a los 3,43 meses. **Conclusión:** Presentamos una técnica quirúrgica que combina los beneficios de la osteotomía de Chevron y la de Mitchell, con excelentes resultados clinicos funcionales.

Palabras clave: Hallux valgus rigidus, osteotomía de Mitchell.
Nivel de Evidencia: IV

INTRODUCTION

The term hallux rigidus refers to degenerative arthritis of the metatarsophalangeal joint. Davies-Colley provided the first description of this condition in 1887 and Cotterill coined the term hallux rigidus. After hallux valgus, it is the most common condition of the big toe.[1]

Hallux valgus rigidus is a common degenerative deformity characterized by subluxation of the first metatarsophalangeal joint, with lateral deviation of the hallux and medial deviation of the first metatarsal (M1). The etiology remains unknown, although there are several theories about it. It predominates in the female sex, with a ratio of 3 to 1.[2-4]

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Many surgical techniques have been published to correct hallux valgus and hallux rigidus deformity, but not for hallux valgus rigidus.

The M1 distal osteotomy can be used to correct varying degrees of hallux deviations.

The most widely used surgical procedures for the correction of hallux rigidus include dorsal cheilectomy, Green-Watermann osteotomy, and arthrodesis for the most severe cases.[1]

In 1958, Mitchell[5] described a double step-cut osteotomy through the neck of M1 causing its lateral displacement and shortening. Originally, the osteotomy was fixated with a circumferential suture placed through two parallel perforations and tied dorsally. Indications for this procedure were: young patients with severe hallux valgus, moderate or severe pain, joint deformity and instability, inability to wear appropriate footwear, and conservative treatment failure.[6] The main complication described as a result of this osteotomy is the recurrence of hallux valgus with pain in the medial eminence.[7]

The hypothesis put forward is that the surgical technique described in this study achieves excellent clinical-functional outcomes in the medium term and is reproducible. Therefore, the objective of this study was to describe the surgical technique and evaluate the results in the medium term.

MATERIALS AND METHODS

Population sample

An observational prospective study was carried out. Between August 2015 and January 2019, 21 patients (23 feet) were treated with hallux valgus associated with grade 2 hallux rigidus, according to the Coughlin and Shurnas classification.[8] This classification divides them into five grades (from 0 to 4), considering the range of motion of the hallux metatarsophalangeal joint, radiographic changes, and clinical manifestations (Table 1). Stage 2 of the classification corresponds to a 10-30° dorsiflexion or a 50-75% loss of range of motion compared to that on the unaffected side. Radiographs show dorsal, lateral, and medial osteophytes, a flattened head, less than 25% involvement of the dorsal joint space, mild to moderate joint space narrowing and sclerosis, without sesamoid involvement. Regarding the clinical signs, the patient feels moderate to intense pain and there is stiffness that can be constant.

Table 1. Coughlin and Shurnas classification

Grade	Arc of motion	Radiograph	Clinical signs
0	40-60° dorsiflexion or 10-20% loss compared to normal side	Normal or minimal	No subjective pain, just stiffness; loss of passive movement on examination
1	Dorsiflexion 30-40° or loss 20-25%	Dorsal osteophyte. Minimal joint impingement. Minimal periarticular sclerosis. Minimal head flattening	Occasional mild or subjective pain and stiffness; pain in the extremities of dorsiflexion or plantarflexion on examination
2	Dorsiflexion of 10-30° or loss of 50-75%	Dorsal, lateral and medial osteophytes. Flattened head. Less than 25% involvement of the dorsal region of the joint space, mild to moderate joint space narrowing and sclerosis, sesamoids unaffected	Subjective moderate to severe pain and stiffness that may be constant; pain on examination just before maximal dorsiflexion or plantarflexion
3	Dorsiflexion of 10° or less, or marked loss of plantarflexion (10° or less)	Like grade 2, but with substantial narrowing; periarticular cystic changes; less than 25% of the dorsal articular region may be involved; enlarged, cystic, or irregular sesamoids	Almost constant subjective pain, throughout the entire arc of motion
4	Stiff joint	Grade 3 plus free bodies and osteochondral defects.	Almost constant/constant pain. Pain throughout the range of motion

Twenty-one patients (23 feet) were evaluated and monitored. All were operated on by the same leg, ankle, and foot specialist surgeon, using a modified Mitchell osteotomy.

The method was selected after a radiographic evaluation and analysis.

Anteroposterior, latero-lateral weight-bearing, and oblique foot radiographs were taken from all patients before surgery to plan it (Figure 1), postoperatively (Figure 2), and 18 months after the intervention (Figure 3) to establish the intermetatarsal angle (IM), hallux valgus angle (HV), distal metatarsal articular angle (DMAA), metatarso-phalangeal joint congruency, interphalangeal angle, M1 height, degree of deformity, degree of injury, hallux joint range of motion, and the presence of pain.

The inclusion criteria were: 1) grade 2 hallux rigidus, 2) IM angle ≥7° and ≤16°, 3) HV angle ≥17° and ≤45°, 4) DMAA angle ≥6° and ≤9°, 5) minimum follow-up of 12 months and 6) surgery with the modified Mitchell technique.

The exclusion criteria were: 1) immature skeleton, 2) lack of follow-up, and 3) history of M1 fracture.

Figure 1. A-C. Preoperative anteroposterior, oblique, and lateral foot radiographs. **D and E.** Anteroposterior and oblique images of the foot before surgery.

Figure 2. Postoperative anteroposterior, oblique, and lateral foot radiographs.

Figure 3. **A-C.** Anteroposterior, oblique, and lateral foot radiographs 18 months after surgery. **D and E.** Anteroposterior and oblique images of the foot at discharge.

Surgical technique

The patients were placed in the supine position after spinal anesthesia. A tourniquet was placed on the thigh. A classic 3 to 5 cm medial hallux approach was performed, the capsule was incised in Y to then access the M1, which underwent a dorsal cheilectomy and a bunionectomy with an oscillating saw. The center of rotation of M1 was marked, which is used to practice the cuts. The first was made from the point at the center of rotation of the head of M1 in the plantar direction at 45° proximally. The following cuts were made at the junction of the head and neck of the M1, perpendicular to it, from side to side. The next cut was made 1-3 mm distal to it, leaving a lateral step no greater than 25% of the total width of the metatarsal. The resulting bone layer was used as an additive graft in the plantar cut. The osteotomy is intrinsically stable. It was also fixated with a 3 mm double-thread screw (Figure 4). An image intensifier was used to confirm the correct position of the osteosynthesis.

Figure 4. Illustrative model of the first metatarsal. **A.** Cut marks, lateral view. **B.** Cut marks, anteroposterior view. **C.** Cut marks, oblique view. **D.** Osteotomy performed, oblique view. **E.** Screw stabilized osteotomy, anteroposterior view.

A Moberg phalangeal osteotomy was also added. It was performed percutaneously, using a medial approach, a dorsal osteotomy of the proximal metaphysis of the first phalanx of the hallux, with resection of a dorsal wedge at that level.

All patients were treated on an outpatient basis and were allowed immediate weight-bearing with a postoperative sandal. Physical therapy was indicated from the third day after surgery onwards.

Oblique anteroposterior and lateral foot radiographs were taken in the immediate postoperative period to assess for possible loss of reduction. The definitive radiographic outcome was considered 18 months or more after surgery.

For the evaluation, the forefoot scale of the American Orthopaedic Foot and Ankle Society (AOFAS) was used before the intervention and 18 months after surgery. This scale assigns 50 points to function, 40 points to pain, and 10 points to alignment. A perfect score of 100 indicates that the patient is pain-free, has full range of motion in the hallux and forefoot, no instability, good alignment, and the ability to walk more than 6 blocks (600 meters) on any surface, without a limp or limitations in daily or recreational activities or need for technical aids for walking.

The following variables were evaluated: age, sex, postoperative follow-up, AOFAS score (pre- and postoperative), affected foot, hallux metatarsophalangeal joint range of motion (pre- and postoperative), loss of reduction, metatarsal head collapse, residual pain, need for insoles for discharge, return to work and sports activity.

Statistical Analysis

Categorical variables are expressed in number and percentage. The interval variables are described with mean and median, according to their distribution and their measures of dispersion (standard deviation) and interquartile interval 25-75. A comparison of continuous variables was performed using the Student's t-test for related samples. A p-value <0.05 was considered statistically significant. For the analysis, the SPSS Statics 25 program was used.

RESULTS

Twenty-one patients (23 feet) were included, 19 women and 4 men, with a mean age of 56.9 years (range 23-81) diagnosed with hallux valgus rigidus. The initial characteristics are shown in Table 2 and the group angle changes in Tables 3 and 4.

Hallux metatarsophalangeal range of motion was 16.95° (range 10-30) before surgery and 34.5° (range 25°-45°) 18 months postoperatively.

The AOFAS score for the foot was 43.17 (range 39-57) before surgery and 94.78 (range 80-100) at 18 months. The postoperative visual analog scale score was 9.3 (range 8-10).

The pain disappeared in all patients, they were evaluated every 7 days until completing 30 days after surgery, then every two months, until 12 months after surgery, and a final control at 18 months.

The HV angles were 30.34° (range 17°-45°) before the intervention; 1.60° (range 0°-9°) in the postoperative period and 3.17° (range 2°-9°) at the time of discharge. The preoperative IM angle was 13.43° (range 7°-16°) and 6.56° (range 3°-12°) postoperatively and 6.56° (range 3°-12°) at discharge. Preoperative, postoperative, and discharge DMAA angles were 7.78° (range 6°-9°), 7.17° (range 6°-9°), and 7.17° (range 6°-9°), respectively.

In addition, a Moberg osteotomy was performed in 13 patients who had limited metatarsophalangeal range of motion during surgery, after the technique described in this study.

The patients resumed their work activity after 16.69 days on average (range 5-60). The return to normal activities occurred, on average, 3.43 months after surgery (range 3-4).

After the osteotomy was consolidated, a lateral displacement of the M1 head was observed in all cases, without collapse or loss of reduction at discharge.

The average surgical time was 25 minutes (range 20-35). No patient required insoles.

Regarding complications, one patient suffered a postoperative infection that required cleaning and intravenous antibiotics without the need to remove the screw.

In no case was a second intervention or subsequent arthrodesis necessary.

Table 2. Sample Description

Variable		Result
Sex, n (%)	Female	19 (82.6)
	Male	4 (17.4)
Age	Mean (SD) Median (IQR 25-75)	57 (15) 56 (49-71)
Affected side, n (%)	Right	13 (56.5)
	Left	10 (43.5)
Previous surgery, n (%)	No	22 (95.7)
	Yes	1 (4.3)
Mitchell, n (%)	Yes No	23 (100) 0 (0)
Moberg n (%)	No	10 (43.5)
	Yes	13 (56.5)
Pre-surgical IM angle	Mean (SD) Median (IQR 25-75)	13 (3) 14 (12-15)
Pre-surgical HV angle	Mean (SD) Median (IQR 25-75)	30 (7) 30 (25-35)
Pre-surgical DMAA angle	Mean (SD) Median (IQR 25-75)	8 (1) 8 (7-9)
Post-surgical IM angle	Mean (SD) Median (IQR 25-75)	7 (2) 7 (6-7)
Post-surgical HV angle	Mean (SD) Median (IQR 25-75)	2 (2) 0 (0-3)
Post-surgical DMAA angle	Mean (SD) Median (IQR 25-75)	7 (1) 7 (7-8)
IM angle at discharge	Mean (SD) Median (IQR 25-75)	7 (2) 7 (6-7)
HV angle at discharge	Mean (SD) Median (IQR 25-75)	3 (2) 3 (2-5)
DMAA angle at discharge	Mean (SD) Median (IQR 25-75)	7 (1) 7 (7-8)
Posterior arthrodesis, n (%)	Yes No	(0) 23 (100)
Return to previous activities (months)	Mean (SD) Median (IQR 25-75)	3 (1) 3 (3-4)
Return to work (days)	Mean (SD) Median (IQR 25-75)	17 (14) 12 (7-21)
Visual Analog Scale	Mean (SD) Median (IQR 25-75)	9 (1) 9 (9-10)
Preoperative AOFAS	Mean (SD) Median (IQR 25-75)	43 (6) 43 (39-57)
Postoperative AOFAS	Mean (SD) Median (IQR 25-75)	95 (6) 100 (90-100)

Abbreviations: IM = intermetatarsal; HV = hallux valgus; DMAA = distal metatarsal articular angle; AOFAS = American Orthopedic Foot & Ankle Society; SD = Standard deviation; IQR 25-75 = interquartile range 25-75.

Table 3. Radiographic results in the immediate postoperative period

Angle	Preoperative Mean (SD)	Postoperative Mean (SD)	p(*)
IM	13 (3)	7 (2)	0.000
HV	30 (7)	2 (2)	0.000
DMAA	8 (1)	7 (1)	0.002

*T-test p-value for related samples. Abbreviations: IM = intermetatarsal; HV = hallux valgus; DMAA = distal metatarsal articular angle; SD = Standard deviation

Table 4. Radiographic results at discharge

Angle	Preoperative Mean (SD)	Postoperative Mean (SD)	p*
IM	13 (3)	7 (2)	0.000
HV	30 (7)	3 (2)	0.000
DMAA	8 (1)	7 (1)	0.002

*T-test p-value for related samples. Abbreviations: IM = intermetatarsal; HV = hallux valgus; DMAA = distal metatarsal articular angle; SD = Standard deviation

DISCUSSION

There are numerous surgical techniques for the treatment of hallux rigidus: dorsal cheilectomies, proximal phalanx osteotomies (described by Bonney and Macnab, and later popularized by Moberg), metatarsal osteotomies (such as the one described by Green-Watermann), Keller resection arthroplasty, interpositional arthroplasty, partial or total prosthetic arthroplasty and, finally, arthrodesis.[1,9]

Although there is no consensus on the ideal treatment for this condition, most authors recommend surgery for the treatment of moderate and severe hallux rigidus.

Many of the distal metatarsal osteotomies are aimed at correcting the metatarsus primus elevatus, although, in recent studies, it was observed that 94% of patients with hallux rigidus did not have such deformity. [10] The shortening obtained with the proposed technique is limited; this osteotomy offers the possibility of lowering the head of M1, shortening or lengthening it depending on how the cut is made.

Baba et al.[11] reported that transfer metatarsalgia occurs with shortenings >8–10 mm. In our series, we did not detect transfer metatarsalgia, we believe it may be due to the fact that it was an osteotomy with limited shortening of 1 to 3 mm, as needed.

The thickness of the extracted bone fragment is important. One of the disadvantages of the classical Mitchell method is the shortening of the first ray causing transfer metatarsalgia.[12] In our technique, the bone fragment extracted did not exceed 2 mm and we did not observe transfer metatarsalgia in the patients evaluated.

The results of the Moberg osteotomy are equivocal, which has led to insufficient evidence of its results to date. [13] In our study, this procedure was not performed routinely, it was only reserved for cases with a restricted metatarsophalangeal range of motion (<45°).

In Mitchell's original technique, fixation of the osteotomy was accomplished by cerclage wiring. A nonunion rate of 4% to 7% was reported.[14] Currently, there are multiple types of fixation in first-ray distal metatarsal osteotomies: Kirschner pins, bioabsorbable pins, screws, staples, sutures, or wire, as the technique was initially popularized.[15] Mitchell's osteotomy is stable *per se*; however, we believe the use of a fixation method is necessary. In this case, we use a self-compressive double-threaded screw. No undesired displacements or loss of reduction or pseudarthrosis were observed.

Angle corrections (IM and HV) pre- and postoperatively were similar to those reported in the literature. Ayoubi et al.[14] reported postoperative IM and HV angle corrections of 5°-7.8° and 27°, respectively. In our research, they were 7° and 28°, respectively.

The AOFAS score was 94 18 months after surgery, a score similar to or higher than that published by other authors.[14]

Our technique modification includes:

1. A distance between cuts of no more than 2 mm, to avoid shortening.
2. A cut of the plantar branch at 45°.
3. The width of the remaining step is not greater than 25% of the total width of the metatarsal.
4. Fixation with a self-compressive double-threaded screw.
5. Autologous bone graft obtained from the distal metatarsal cut to descend the first metatarsal head.

A complication occurred: one patient required cleaning and antibiotics, without the need to remove the screw. As mentioned before, this osteotomy is stable and maintains reduction by itself; therefore, material removal is not problematic, as it can be with other M1 osteotomies, as long as it is protected from weight-bearing.

This study has several limitations: its non-randomized prospective design, a very wide age range, and a relatively small number of cases. As strengths, the description of a new surgical technique and a long-term follow-up period can be mentioned.

CONCLUSION

The results of this study demonstrate that the modified Mitchell technique and stabilization of the osteotomy with a screw are effective solutions for the treatment of moderate hallux valgus rigidus. This surgical technique is low-cost, reliable and reproducible.

Conflict of interest: The author declares no conflicts of interest

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