Bösch vs MICA Techniques in Hallux Valgus Surgery. Medium-Term Prospective Comparative Radiographic Analysis

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ABSTRACT

Introduction: Multiple surgical treatments for the hallux valgus have been described. The purpose of this study is to compare the radiological results for the angular correction and its stability on the middle term between two percutaneous techniques (MICA versus BOSCH technique). **Materials and methods:** Prospective comparative analysis of surgically treated patients with hallux valgus by two percutaneous techniques (BOSCH group: 42 feet; MICA group: 36 feet) in homogenous groups. Intermetatarsal, metatarsophalangeal and distal metatarsal articular angle corrections were compared, as well as the correction power of both osteotomies and its stability in the middle term. Postoperative complications were recorded. Minimum follow-up: 6 months. **Results:** Average angle correction of MTP, IM y DMAA 6 months after surgery in Bosch group: 20,22°; 7,74°; 8,26°; MICA: 15,8°; 1,6° and 1,98° respectively. BOSCH group had a higher IM correction power. There were no significant statistical differences between both groups in the loss of correction by 6 weeks to 6 months; except for the MTP angle in the MICA group. MICA presented a better correction of the DMAA in time. Postoperatively, MICA had 4 complications, while BOSCH 8. **Conclusions:** We obtained good results with both techniques in the treatment of moderate hallux valgus. However, patients undergoing the Bosch technique had greater correction on the intermetatarsal angle in the mid-term follow-up. Although the MTP angle correction decreased between 6 weeks and 6 months in MICA technique, the values remained within normal 20° of valgus MTP.

Key words: Minimally invasive surgery; Bosch osteotomy; MICA technique; percutaneous surgery.

Level of Evidence: II

Estudio prospectivo de cirugía de hallux valgus con técnicas de Bösch y MICA. Análisis radiográfico comparativo a mediano plazo

RESUMEN

Introducción: Existen múltiples tratamientos quirúrgicos del hallux valgus. El propósito de este estudio fue comparar los resultados radiográficos de corrección angular y su mantenimiento a mediano plazo, entre dos técnicas percutáneas: MICA y Bösch. **Materiales y Métodos:** Análisis prospectivo comparativo de pacientes sometidos a cirugía de hallux valgus mediante dos técnicas percutáneas (grupo Bösch: 42 pies, grupo MICA: 36 pies). Se compararon las correcciones de los ángulos IM, MTF y AMD, y el poder de corrección de ambas osteotomías y su mantenimiento a mediano plazo. Se registraron las complicaciones posoperatorias. Seguimiento mínimo: 6 meses. **Resultados:** La corrección promedio de los ángulos IM, MTF y AMD fue: 20,22°; 7,74°; 8,26° a los 6 meses en el grupo Bösch; y de 15,8°; 1,6° y 1,98° en el grupo MICA. El potencial de corrección IM fue mayor en el grupo Bösch. No hubo diferencias significativas entre ambos grupos en cuanto a la pérdida de corrección entre las 6 semanas y los 6 meses, salvo el ángulo MTF en el grupo MICA. La corrección del ángulo AMD fue mejor en el tiempo con la técnica MICA. Hubo 4 complicaciones con la técnica MICA y 8 con la técnica de Bösch. **Conclusiones:** Ambas técnicas logran una corrección adecuada del hallux valgus moderado. Sin embargo, el poder de corrección del ángulo IM a mediano plazo fue mayor con la técnica de Bösch. En el otro grupo, aunque se perdió la corrección del ángulo MTF entre las 6 semanas y los 6 meses, los valores se mantuvieron dentro de los 20° de valgo MTF.

Palabras clave: Cirugía mínimamente invasiva; hallux valgus; osteotomía de Bösch; cirugía MICA; cirugía percutánea.

Nivel de Evidencia: II

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INTRODUCTION

Hallux valgus, a term coined by Carl Hueter to define the subluxation of the first metatarsophalangeal (MTP) joint, is characterized by a metatarsus primus varus and a lateral deviation of the great toe. Nowadays, it is known that the subluxation of the MTP joint may not be present in hallux valgus.[1] It is multifactorial in its etiology.[2] It is much more frequent in women.[3,4] The reason for consultation is usually pain, but also, very frequently, aesthetic concerns or discomfort when using certain types of footwear.

In adults, the correction is achieved surgically. In mild to moderate hallux valgus, good results have been obtained with distal osteotomies of the first metatarsal, with intermetatarsal (IM) and MTP angles not exceeding 15° and 30°, respectively.[5] Distal Chevron osteotomy, popularized by Austin and Leventen,[6] is currently accepted as an excellent alternative to treat mild or moderate hallux valgus; good results are obtained both from the clinical-symptomatic point of view and in the radiographic angular correction.[7]

Percutaneous or minimally invasive surgery has become increasingly popular; forefoot surgery outcomes are comparable to those obtained with open procedures. The advantages are a faster surgical procedure, less surgical trauma and a faster recovery.[8] For that reason, in 1990, Bösch[9] published a percutaneous technique for hallux valgus. It consists of a subcapital osteotomy performed perpendicular to the first metatarsal diaphysis, in order to achieve a lateral cephalic displacement of 75% or more of the total diameter of the metatarsal diaphysis, thus placing the medial cortical part of the distal osteotomized fragment in contact with the lateral cortical part of the proximal fragment.[10]

In 2015, making use of the advantages of Chevron osteotomy, Redfern and Vernois published a percutaneous technique they called *Minimally Invasive Chevron Akin* (MICA)[11,12], where they report the benefits of combining a percutaneous distal metatarsal Chevron osteotomy with osteosynthesis and a percutaneous Akin osteotomy of the proximal phalanx.

Due to the published follow-up period and the levels of evidence (III and IV), the percutaneous techniques described remain controversial.[13]

There are no studies comparing the results, benefits and complications of Bösch osteotomy and MICA technique. Since they are both percutaneous techniques, we consider important to evaluate their advantages and disadvantages, and their radiographic results regarding angular correction of hallux valgus deformity.

The main aim of this study was to conduct a comparative analysis of the radiographic results of IM, MTP and distal metatarsal articular (DMAA) angle correction, as well as their medium-term evolution, between two minimally invasive techniques to treat hallux valgus (MICA and Bösch techniques).

The secondary aim was to evaluate the achievement of normal angles after surgery with both techniques, as well as their complications.

MATERIALS AND METHODS

It is a homogeneous systematic prospective cohort study. Patients who underwent surgery for symptomatic hallux valgus were prospectively and comparatively analyzed and followed over time. Two groups of similar patients were formed, based on the type and level of deformity of the first ray, functional activity, age and sex. One group was treated with Bösch percutaneous technique, stabilized with a screw and a Kirschner wire; the other group was treated with MICA percutaneous technique. All patients underwent surgery between April 2017 and February 2019.

Minimum time to evaluate the final radiographic correction was set at 6 months after surgery, assuming osteotomies and soft tissues had completely healed, and thus angles could be considered definitive. For that reason, minimum follow-up was 6 months, and maximum was 20 months.

The severity of the deformity was defined according to Coughlin,[14] using the value of the MTP angle in the preoperative period: mild deformity (16-20°), moderate deformity (21-39°) and severe deformity (≥40°). All of them had a moderate hallux valgus deformity.

A relapse in the deformity was defined as the presence of an MTP angle >20° in the postoperative period.[15]

Population Sample

78 feet of 69 patients were evaluated; nine patients had bilateral pathology. Two cohorts were formed based on the surgical technique used (Table 1):

Table 1. Characteristics of the two analyzed groups

Technique	MICA	Bösch
Number of feet	36	42
Average age	46.6	51.2
Sex	31 females 5 males	38 females 4 males
Side	21 left 15 right	19 left 23 right
Metatarsophalangeal angle	36 moderate	42 moderate
Bilateral hallux valgus	4	5
Total of patients	32	37

Group 1 (Bösch): 42 feet of 37 patients. 90.4% were women. The surgical technique was a Bösch percutaneous osteotomy stabilized with an osteosynthesis by double-cannulated screws, and intramedullary Kirschner wire fixation. In all cases, the conjoint tendon was released.

Group 2 (MICA): 36 feet of 32 patients. 86% were women. The surgical technique was a percutaneous distal Chevron osteotomy of the first metatarsal with lateral displacement, stabilized with two double-cannulated screws and percutaneous phalangeal Akin osteotomy.

All surgeries were performed in the same institution and by three foot, ankle and leg surgeons.

Inclusion criteria were: 1) moderate symptomatic hallux valgus and 2) age >18 years. Exclusion criteria were: 1) previous hallux valgus surgery; 2) rheumatoid arthritis or other destructive arthritis; 3) severe deformities; 4) clinically evident instability of the cuneometatarsal joint; 5) neuromuscular disease; 6) lack of follow-up.

Radiographic analysis

Weightbearing dorsoplantar and strict lateral radiographs were analyzed. The radiographs were taken before surgery, then 6 weeks and 6 months after surgery. With these data, the angular correction achieved in the early postoperative period and 6 months after surgery were compared. This last time period was considered enough for the consolidation and maturity of osteotomies and soft tissues. Angular alterations after 6 months were attributed to other causes and not to the surgical technique itself (e.g. inadvertent cuneometatarsal instability).

The postoperative radiographic assessment was conducted by surgeons who had not treated the patients (Figures 1 and 2). In this way, the loss or maintenance of correction for both surgical techniques were evaluated. All images were digitized using software (MB Rouler® 4.0 version); the following parameters were calculated: a) MTP angle, b) IM angle using Miller's measuring technique[16] and c) DMAA angle, using the technique mentioned by Deenik[17].

In the statistical study, both groups were analyzed on the percentage of angular correction and the achievement of angles within normal values. The loss of correction at six months post-surgery was corroborated.

In each group, the average degrees of the angles were measured in the weightbearing dorsoplantar and strict lateral radiographs, before surgery, 6 weeks and 6 months post-surgery. Averages and standard deviations of the samples were calculated.

For the analysis of differences in the distribution of a variable in both groups, a paired sample t-test was used. A value $p < 0.05$ was considered statistically significant.

Through the Mann-Whitney test, the radiographic assessment of both groups were compared (comparison between techniques).

Figure 1. Postoperative angular measurements (Bösch technique).

Figure 2. Postoperative angular measurements (MICA technique).

The evolution of measurements in time (maintenance of the achieved correction) in each group were compared with Student's test for similar variances.

Lastly, the presence of differences in the evolution was determined according to the group (Bösch vs. MICA technique), by Student's t test.

Since two techniques were applied to treat the same condition, in similar and homogeneous populations, we tried to reduce the influence of uncontrolled variables to the minimum.

Surgical techniques

Summary of (modified) Bösch technique[18]

The patient is positioned in dorsal decubitus. The conjoint tendon is released with percutaneous technique from the first dorsal space. A medial periungueal incision of the first toe is performed and a 2 mm Kirschner wire is advanced to the distal metaphysis of the first metatarsal. A transversal osteotomy is performed on the first metatarsal with a long shannon burr. Under the guidance of an image intensifier, the metatarsal angular correction (lateral displacement) is performed and an intramedullary Kirschner wire is advanced and anchored at the base of the same bone. Percutaneous stabilization with a 3 mm double-cannulated screw and skin synthesis are performed (Figure 3).

Summary of MICA technique

It combines a percutaneous Chevron osteotomy through a medial distal metatarsal portal with a long, extra-articular shannon burr; and a percutaneous Akin osteotomy with a short shannon burr. The metatarsal incision must be initially oriented with a plantar angle of 10°, and then performed on both sides (plantar and dorsal). The metatarsal osteotomy is stabilized after the lateral gliding of the head with two long parallel double-cannulated screws, from the proximal metaphysis of the metatarsal to the head of the same bone (Figure 4); and eventually the Akin with a cannulated screw.

Figure 3. Bösch technique with osteosynthesis.

Figure 4. MICA technique in metatarsal.

RESULTS

The average age was 48.9 years. In group 1, it was 51.2 years (range 23-77) and, in group 2, 46.6 years (range 18-75). 9 patients were male and 69 were female. 40 left feet and 38 right feet were treated.

In group 1 (Bösch), 38 of the 42 feet belonged to women and 4 belonged to men. 19 feet were left and 23 feet were right. All patients presented moderate hallux valgus; five of them were bilateral.

In group 2 (MICA), 5 of the 36 feet belonged to men and 31 feet belonged to women. In 4 cases, the pathology was bilateral. All patients presented moderate hallux valgus. 21 feet were left and 15 feet were right.

Group 1 (Bösch): analysis of radiographic measurements

Average correction of MTP, IM and DMAA angles was 20.79°; 8.14°; and 8.65° at six weeks; and 20.22°; 7.74° and 8.26° at six months, respectively.

The differences between preoperative and six weeks postoperative IM, and between preoperative and six months postoperative were statistically significant (both $p < 0.005$). The relationship between the IM angle at 6 weeks and at 6 months post-surgery was not statistically significant ($p = 0.033$). This shows that there was no significant loss of correction between 6 weeks and 6 months post-surgery.

The differences between preoperative and 6 weeks postoperative MTP angle; and between preoperative and six months postoperative were statistically significant (both $p < 0.005$). The relationship between the IM angle at 6 weeks and at 6 months post surgery was not statistically significant ($p = 0.34$). This shows that there was no significant loss of correction between 6 weeks and 6 months post-surgery.

Regarding DMAA correction, the relationships between preoperative and 6 weeks postoperative, and between preoperative and six months postoperative were statistically significant in both measurements ($p < 0.005$). Loss of correction between 6 weeks and 6 months post-surgery was not significant ($p = 0.50$).

Group 2 (MICA): analysis of radiographic measurements

Average correction of MTP, IM and DMAA angles was 16.83°; 1.8° and 2.06° at 6 weeks; and 15.8°; 1.6° and 1.98° at 6 months, respectively.

The difference between preoperative and six weeks postoperative IM angle was statistically significant ($p < 0.005$), as well as between preoperative and six months postoperative ($p < 0.005$). The relationship between the IM angle at 6 weeks and at 6 months post-surgery was not statistically significant. ($p = 0.324$). This shows that there was no significant loss of correction.

The differences between preoperative and 6 weeks postoperative MTP angle; and between preoperative and six months postoperative were statistically significant (both $p < 0.005$). The relationship between the MTP angle at 6 weeks and at 6 months post-surgery was statistically significant ($p = 0.010$), which evidences a loss of MTP correction with MICA technique.

Regarding DMAA correction, the relationships between preoperative and 6 weeks postoperative and between preoperative and six months postoperative were statistically significant in both measurements ($p < 0.005$). Loss of correction between 6 weeks and 6 months post-surgery was not significant ($p = 0.57$). There was no loss of correction.

Relationship between the two groups

Preoperative measurements (Table 2)

Except for the preoperative DMAA angle in both groups (which presented a significant difference, $p < 0.005$), the rest of the measured angles did not present significant differences in either group.

Measurement 6 weeks post-surgery, both groups

1. The average percentage of angular correction of the IM angle was 61% in patients treated with Bösch technique and 16% with MICA technique ($p < 0.005$).

2. The MTP angle had a correction percentage of 65% with Bösch technique and of 59.4% with the other technique ($p > 0.05$).

3. The DMAA had a correction percentage of 49% with Bösch technique and of 33% with MICA technique ($p < 0.05$) when both techniques were statistically compared. It is worth mentioning that, in the MICA group, a 100% of normal angles was achieved in the evaluated patients, although the initial angular values were comparatively lower.

Table 2. Average angular values before surgery in both groups and comparative significance.

Variable	Group 1	Group 2	Average (1)	Average (2)	p (2-tailed)
Metatarsophalangeal angle	Bösch	MICA	30.85	28.33	0.07
Intermetatarsal angle	Bösch	MICA	12.69	11.47	0.055
Distal metatarsal articular angle	Bösch	MICA	17.61	6.23	0.0001

Measurement 6 months post-surgery and loss of angular correction

Bösch Group (Table 3)

a) Average loss of IM angle correction was 0.3° between 6 weeks and 6 months ($p = 0.56$).

b) Average loss of MTP angle correction was 0.57° between 6 weeks and 6 months ($p = 0.34$).

c) Average loss of DMAA angle correction was 0.38° between 6 weeks and 6 months ($p = 0.50$).

d) Regarding final correction to normal angles: (Figures 5-7)

- 95.3% of the cases presented normal IM angles 6 months post-surgery. Only two had an angle of 11° and one of 12° (the remaining 4.7%).

- 92.85% of the cases presented normal MTP angles 6 months post-surgery. The remaining 7.14% (3 cases) had relapsed MTP angles.

- 33.33% of the cases presented abnormal DMAA angles 6 months post-surgery.

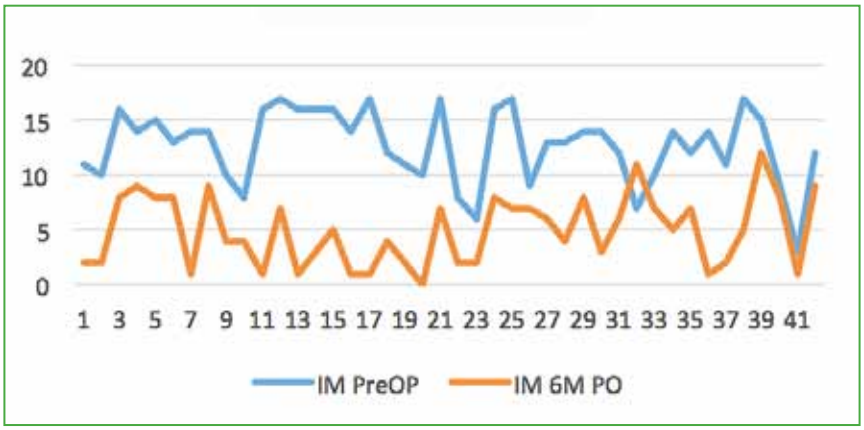

Figure 5. Bösch technique: intermetatarsal (IM) angle correction. Comparison between preoperative and 6-month postoperative angles.

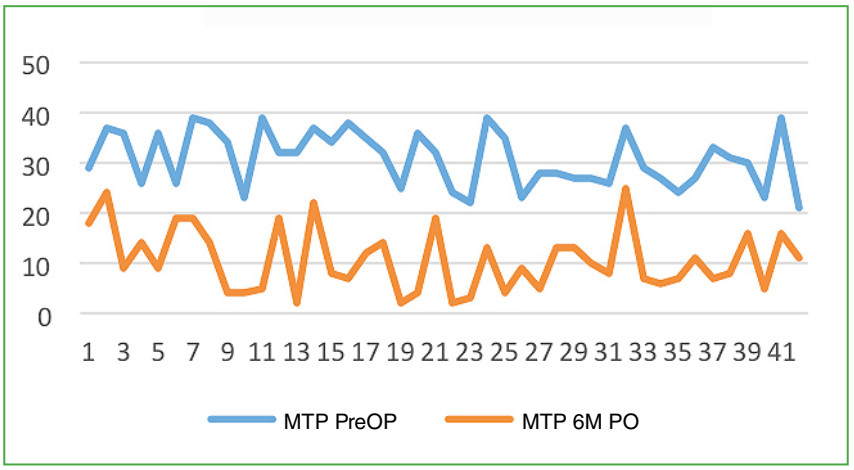

Figure 6. Bösch technique: metatarsophalangeal (MTP) angle correction. Comparison between preoperative and 6-month postoperative angles.

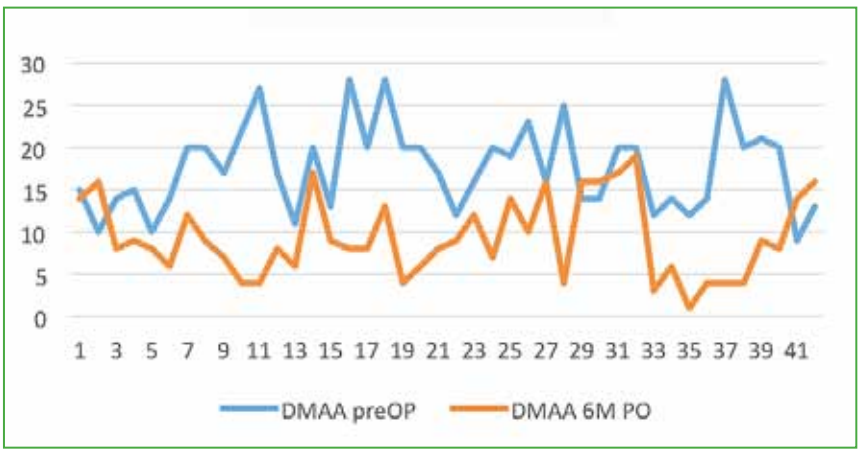

Figure 7. Bösch technique: distal metatarsal articular angle (DMAA) correction. Comparison between preoperative and 6-month postoperative angles.

Table 3. Loss of angular correction, average values between 6 weeks and 6 months post-surgery, in the Bösch group.

Variable	Group 1	Average (1) angle 6 weeks post-surgery	Average (1) angle 6 months post-surgery	Average (1) Loss	p
Intermetatarsal angle	Bösch (n = 42)	4.55	4.95	0.30	0.56
Metatarsophalangeal angle	Bösch (n = 42)	10.07	10.64	0.57	0.34
Distal metatarsal articular angle	Bösch (n = 42)	8.97	9.35	0.38	0.50

MICA Group (Table 4)

a) Average loss of IM angle correction was 0.17° between 6 weeks and 6 months (p = 0.32, insignificant).

b) Average loss of MTP angle correction was 1° between 6 weeks and 6 months (p = 0.01, significant).

c) Average loss of DMAA angle correction was 0.08° between 6 weeks and 6 months (p = 0.57).

d) Regarding final correction to normal angles: (Figures 8-10)

- 77.8% of the cases presented normal IM angles 6 months post-surgery. Eight had angles between 11° and 15° (the remaining 22.2%).

- All of the cases presented normal MTP angles 6 months post-surgery.

- All of the cases presented normal DMAA angles 6 months post-surgery.

No complications were reported during surgery in neither of the groups. Eight postoperative complications arose in group 1 (Bösch) and four with Chevron technique (Figure 11). However, the complication rate between the two techniques was similar (chi-square, p = 0.41). In group 1 (Bösch), there were five cases of cellulitis in the insertion site of the Kirschner wire, one implant breakage, one neuritis and one osteomyelitis. In group 2 (MICA), there were two cases of transfer metatarsalgia, one case of osteosynthesis material migration which required removal, and one hallux valgus relapse

Table 4. Loss of angular correction, average values between 6 weeks and 6 months post-surgery, in the MICA group.

Variable	Group 2	Average (2) angle 6 weeks post-surgery	Average (2) angle 6 months post-surgery	Average (2) Loss	p
Intermetatarsal angle	MICA (n =36)	9.63	9.80	0.17	0.32
Metatarsophalangeal angle	MICA (n =36)	11.50	12.55	1.05	0.01
Distal metatarsal articular angle	MICA (n = 36)	4.17	4.25	0.08	0.57

MICA = *Minimally Invasive Chevron Akin.*

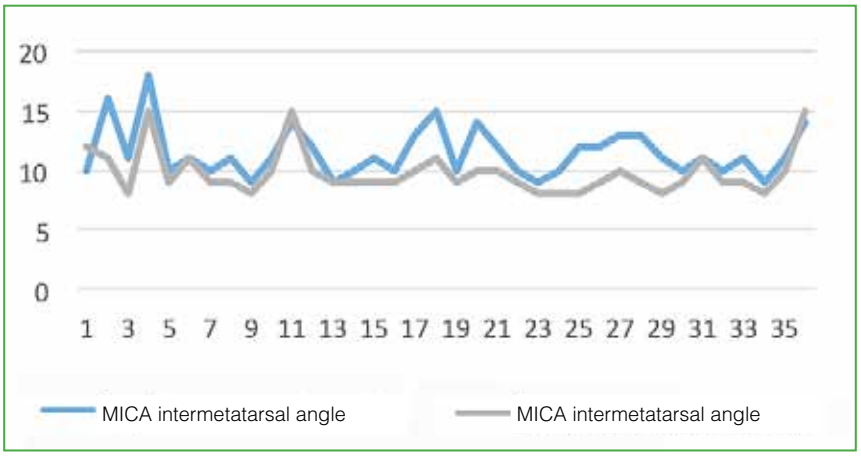

Figure 8. MICA technique: intermetatarsal (IM) angle correction. Comparison between preoperative and 6-month postoperative angles.

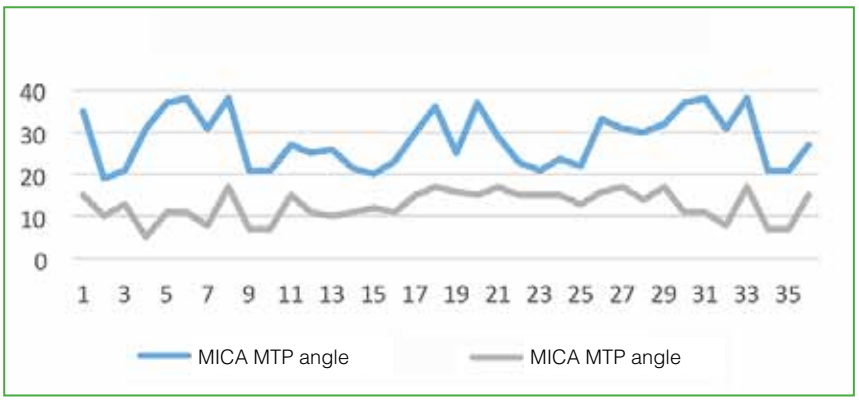

Figure 9. MICA technique: metatarsophalangeal (MTP) angle correction. Comparison between preoperative and 6-month postoperative angles.

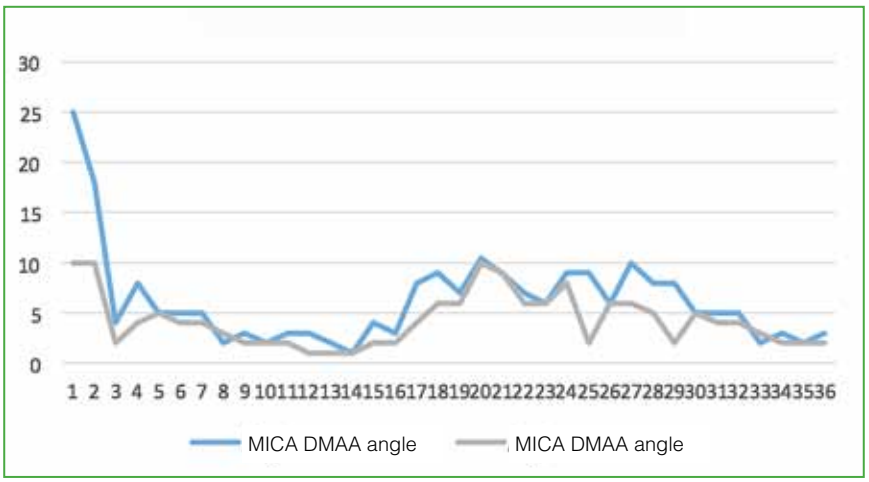

Figure 10. MICA technique: distal metatarsal articular angle (DMAA) correction. Comparison between preoperative and 6-month postoperative angles.

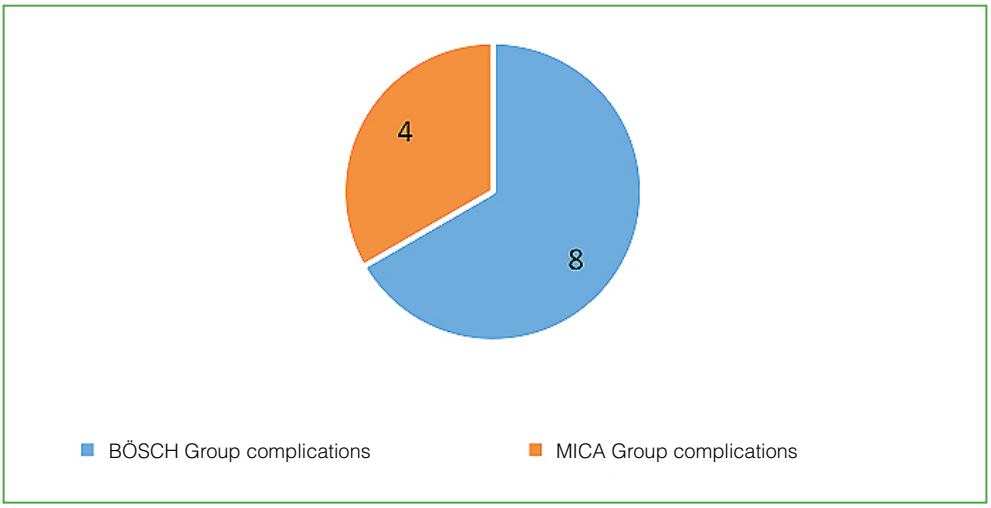

Figure 11. Complications for each technique.

DISCUSSION

Minimally invasive foot surgery started to gain popularity in the decade of 1980. Over the last 20 years, more and more surgeons have been performing it.

Portaluri[19] and Magnan[20] published a series of 118 feet treated with Bösch technique without screws and with an average follow-up of 35.9 months, and mentioned that clinical outcomes are comparable to those obtained by conventional open surgery.

Giannini et al.[21] performed a randomized study comparing the clinical-radiographic outcomes of 40 patients with bilateral hallux valgus. In one foot, they performed a scarf osteotomy and, in the other, a percutaneous Bösch surgery without screw. They did not find statistically significant differences in postoperative angular measurements. However, percutaneous surgery was simpler, less aggressive, and performed in less time. In this study, both surgeries are percutaneous and achieved acceptable (statistically significant) radiographic corrections in the measured angles. Nonetheless, Bösch osteotomy evidenced a greater correction power than MICA technique on the IM angle (61% vs. 16%, respectively).

Brogan[22] compared conventional and percutaneous Chevron osteotomy. Postoperative clinical and radiographic scores in all angles were substantially improved in both groups ($p < 0.001$), but there were no statistically significant differences in angular improvement between the open group and the minimally invasive group ($p > 0.05$). In our study, the corrections achieved with MICA technique (which includes percutaneous Chevron) were statistically significant (100% of normal DMAA and MTP angle values, and 77,8% of IM angle).

Although Vernois et al.[23] state that MICA technique can be performed on severe angles, displacing more than 80% of the head to the lateral, we believe such an exaggerated angle could be risky or generate shortenings or unacceptable displacements into the first space. Therefore, we have not performed this technique on IM angles >18°. The authors also mention that the fact of being extra-articular and not requiring an intramedullary Kischner wire enables a faster functional rehabilitation. In our study, we evaluated radiographic corrections, not functionality.

In the studies, there are no mentions to the cost of the implants, which, logically, are higher in MICA technique than in Bösch technique (since it requires double or triple osteosynthesis, 2 or 3 screws).

We have not found publications comparing Bösch osteotomy with MICA surgery. From our research, we can infer that both techniques achieved good radiographic results regarding the correction of the deformity. However, Bösch technique presented a greater power of correction of the IM angle and a lesser power of correction of the DMAA angle (it only corrected 33.3% of the cases to normal values).

Iannó et al.[24] published a series of cases of percutaneous Bösch surgery without osteosynthesis and gave a warning about the high rate of complications, among them, four cases of vicious consolidation, osteonecrosis and 16 cases of relapse. In our study, with a statistically considerable number, there were no relapses, osteonecrosis, nor hallux varus.

The strengths of our study are: an exhaustive statistical analysis, a prospective follow-up of both groups and the presentation of an unprecedented comparison in the literature.

As weaknesses, we mention the number of presented cases and the lack of long-term follow-up. We can also mention the fact that we did not measure lateral radiographs in the postoperative period, which would have evaluated the cephalic descent or ascent of the metatarsal. Moreover, we believe the learning curve of MICA technique could have been a weakness factor in the results obtained. Lack of clinical assessment is not mentioned as a weakness, since it was not an aim of this study.

CONCLUSIONS

Both Bösch surgery stabilized with screws and MICA surgery adequately correct moderate hallux valgus. The power of correction of the IM angle on the medium term was greater in patients treated with Bösch percutaneous surgery while correction and maintenance of the DMAA angle were greater in patients who underwent MICA surgery.

During their evolution, both techniques presented the same outcomes regarding loss of correction and postoperative complications.

Conflict of interests: Authors claim they do not have any conflict of interest.

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REFERENCES

1. Coughlin M, Saltzman C, Anderson R, Mann R. *Mann's surgery of the foot and ankle*. Philadelphia: Saunders/Elsevier; 2014.
2. Mann RA, Coughlin MJ. Hallux valgus-etiology, anatomy, treatment and surgical considerations. *Clin Orthop Relat Res* 1981;157:31-41. PMID: 7249460
3. Coughlin MJ, Thompson FM. The high price of high-fashion footwear. *Instr Course Lect* 1995;44:371-7. PMID: 7797875
4. Coughlin MJ. Hallux valgus in men: effect of the distal metatarsal articular angle on halux valgus correction. *Foot Ankle Int* 1997;18:463-70. https://doi.org/10.1177/107110079701800802
5. Amor RT. *Pierna, tobillo y pie*. Buenos Aires: Cámara Argentina del Libro; 2009.
6. Austin DW, Leventen EO. A new osteotomy for hallux valgus. *Clin Orthop Relat Res* 1981;157:25. PMID: 7249456
7. Schneider W, Aigner N, Pinggera O, Knahr K. Chevron osteotomy in hallux valgus. Ten-year results of 112 cases. *J Bone Joint Surg Br* 2004;86(7):1016-20. https://doi.org/10.1302/0301-620X.86B7.15108
8. Maffulli N, Longo UG, Marinozzi A, Denaro V. Hallux valgus: effectiveness and safety of minimally invasive surgery. A systematic review. *Br Med Bull* 2011;97:149-67. https://doi.org/10.1093/bmb/ldq027
9. Bösch P, Markowski H, Rannicher V. Technik und erste ergebnisse der subkutanen distalen metatarsale-I-osteotomie. *Orthopädische Praxis* 1990;26:51-6.
10. Sotelano P, Migues A. Tratamiento percutáneo del hallux valgus. Técnica de Bosch. *Rev Asoc Argent Ortop Traumatol* 2007;72(3):233-41. https://www.aaot.org.ar/revista/2007/n3_vol72/art5.pdf

11. Redfern D, Vernois J, Legre BP. Percutaneous surgery of the forefoot. *Clin Podiatr Med Surg* 2015;32:291-332. https://doi.org/10.1016/j.cpm.2015.03.007
12. Redfern D, Vernois J. Minimally invasive Chevron Akin (MICA) for correction of hallux valgus. *Tech Foot Ankle Surg* 2106;15(1):3-11. https://doi.org/10.1097/BTF.0000000000000102
13. Perera AM, Redfern A, Singh D, Lomax A. Minimally invasive forefoot surgery. *J Trauma Orthop* 2015;3(1):50-5.
14. Coughlin MJ. Instructional Course Lectures, The American Academy of Orthopaedic Surgeons – Hallux valgus. *J Bone Joint Surg Am* 1996;78:932-66.
15. Chiang CC, Lin CF, Tzeng YH. Distal linear osteotomy compared to oblique diaphyseal osteotomy in moderate to severe hallux valgus. *Foot Ankle Int* 2012;33:479-86. https://doi.org/10.3113/FAI.2012.0479
16. Miller JW. Distal first metatarsal displacement osteotomy: its place in the schema of bunion surgery. *J Bone Joint Surg Am* 1974;56:923-31. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.1033.3979&rep=rep1&type=pdf
17. Deenik AR, de Visser E, Louwerens JWK, Malefijt MW, Draijer FF, de Bie RA. Hallux valgus angle as main predictor for correction of hallux valgus. *BMC Musculoskelet Disord* 2008;9:70. https://doi.org/10.1186/1471-2474-9-70
18. Bosch P, Wanke S, Legenstein R. Hallux valgus correction by the method of Bosch: a new technique with a seven-to-ten-year follow-up. *Foot Ankle Clin* 2000;5(3):485-98. PMID: 11232393
19. Portaluri M. Hallux valgus correction by the method of Bösch: a clinical evaluation. *Foot Ankle Clin* 2000;5(3):499-511. PMID: 11232394
20. Magnan B, Samaila E, Viola G, Bartolozzi P. Minimally invasive retrocapital osteotomy of the first metatarsal in hallux valgus deformity. *Oper Orthop Traumatol* 2008;20(1):89-96. https://doi.org/10.1007/s00064-008-1231-0
21. Giannini S, Faldini C, Vannini F, Bevoni R, Biagini C. Surgical treatment of hallux valgus: a clinical prospective randomized study comparing linear distal metatarsal osteotomy with scarf osteotomy. *Orthop Proceed* 2009;91B(Supp I):162.
22. Brogan K. Minimally invasive and open distal Chevron osteotomy for mild to moderate hallux valgus. *Foot Ankle Int* 2016;37(11):1197-1204. https://doi.org/10.1177/1071100716656440
23. Vernois J, Redfern D. Percutaneous surgery for severe hallux valgus. *Foot Ankle Clin* 2016;21(3):479-93. https:/doi.org/ DOI: 10.1016/j.fcl.2016.04.002
24. Iannó B, Familiari F, De Gori M, Galasso O, Ranuccio F, Gasparini G. Midterm results and complications after minimally invasive distal metatarsal osteotomy for treatment of hallux valgus. *Foot Ankle Int* 2013;34(7):969-77. https://doi.org/10.1177/1071100713481453