DOI: https://doi.org/10.30795/scijfootankle.2018.v12.784

ORIGINAL ARTICLE

Scientific Journal of the Foot & Ankle

Modified osteotomy with elevation of the first metatarsal: preliminary results

Osteotomia modificada de elevação do primeiro metatarso: resultados preliminares

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ABSTRACT

Objective: The main objective of this study is to describe the preliminary results of modified osteotomy with elevation of the first metatarsal to repair cavovarus foot deformities.

Methods: In a five-case series, radiographic findings related to the modified osteotomy with elevation of the first ray were analysed.

Results: Five patients who underwent a modified osteotomy with elevation were followed up for a minimum of six months. One hundred percent consolidation rates were observed, with no complications related to the materials, such as screw breakage, screw loosening and/or pseudoarthrosis (0% of the cases), regardless of age and gender.

Conclusion: The modified technique generates an osteotomy plane that is more horizontal, reducing the technical difficulty and resulting in less risk of loss of fixation during passage of the screw. Using a single screw for fixation reduces the cost of the procedure and pseudarthrosis rates.

Level of Evidence IV; Therapeutic Studies; Case series.

Keywords: Talipes Cavus; Osteotomy; Metatarsus.

RESUMO

Objetivo: O objetivo primário deste trabalho é descrever os resultados preliminares da técnica de osteotomia modificada de elevação do primeiro metatarso para correção de pé cavo varo.

Métodos: Trata-se de uma série de 5 casos em que foram analisados achados radiográficos relacionados à osteotomia modificada de elevação do primeiro raio.

Resultados: Foram avaliados 5 pacientes submetidos à osteotomia de elevação modificada, com seguimento mínimo de seis meses. Observou-se índices de consolidação de 100%, com ausência de complicações referentes ao material como quebra do parafuso, soltura e/ou pseudartrose (0% de casos associados), independentemente da idade e do sexo do paciente.

Conclusão: A técnica modificada torna o plano da osteotomia mais horizontalizado, diminuindo a dificuldade técnica e trazendo menor risco de perda da fixação durante a passagem do parafuso. Há diminuição de custo do procedimento por utilização de um único parafuso para fixação e das taxas de pseudartrose.

Nível de Evidência IV; Estudos Terapêuticos; Série de casos.

Descritores: Pé Cavo; Osteotomia; Metatarso.

How to cite this article: Bueno DK, Ortiz RT, Santos TP, Sposeto RB, Macedo RS, Fernandes TD. Modified osteotomy with elevation of the first metatarsal: preliminary results. Sci J Foot Ankle. 2018;12(2):140-4.

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Conflicts of interest: none. **Source of funding:** none.
Date received: March 15, 2018. **Date accepted:** May 22, 2018. **Online:** June 30, 2018.

INTRODUCTION

Cavovarus foot is a complex deformity characterized by excessive elevation of the foot longitudinal arch due to rigid plantar flexion of the first ray, with variable degrees of hindfoot varus, forefoot adduction and claw-toe deformity[1-5].

A cavovarus foot can potentially become a rather debilitating condition by directing the stress of ambulation to misaligned structures in the ankle, hindfoot, midfoot and forefoot[1-4].

An individual with a cavovarus foot experiences mechanical and anatomical changes that create difficulty in adapting to different types of footwear and activities. Joint flexibility is decreased due to the vertical axis of the subtalar joint and rotational blockage of the midtarsal joints during walking. The toes may present a claw-like appearance due to hyperextension of the metatarsophalangeal joints[2,3,5].

More than one pattern of muscle imbalance may be present in the aetiology of the deformity given the broad spectrum of neuromuscular pathologies involved, such as weakness of the anterior tibialis muscle, which is characteristic of Charcot-Marie-Tooth disease. The plantar fascia may become more retracted due to hyperactivity of the intrinsic foot muscles and the (short and long) plantar flexor muscles. This shortening is associated with elevation of the plantar arch, plantar flexion of the metatarsals, adduction of the forefoot relative to the hindfoot and external rotation of the tibia relative to the hindfoot[3,5].

The most significant components associated with plantar flexion of the first metatarsal are the previously described mechanisms of intrinsic foot muscle shortening, extensor hallucis longus tendon hyperfunction and fibularis longus muscle hyperactivity. Plantar flexion of the first metatarsal is initially flexible, but with the evolution of the disease, the deformity progressively stiffens[3,5].

A patient with a cavovarus foot may present pain and callosities caused by mechanical overload of misaligned structures, reduction in the range of motion and imbalance of the muscles controlling stabilization of the subtalar complex. The initial evaluation also indicates ankle instability, bone deformities and true or apparent displacements, such as posteriorisation of the fibula[3].

The radiographic evaluation includes anteroposterior and profile views of loaded feet and an axial view of the calcaneus. Meary's angle is considered altered when greater than 5º, which indicates the presence of deformity. In addition, a calcaneal-ground angle greater than 30º and a Hibbs angle greater than 90º indicate calcaneal verticalisation. The navicular bone projects upwards, and two very typical radiographic features are fibular posteriorisation and a flattened talar dome[1,3].

Clinical investigation to identify the aetiology of the deformity is important. Some neurological syndromes associated with cavovarus foot are progressive, and this progression may alter the treatment that will be administered to the patient. In such cases, therapies with more lasting results should be adopted.

Conservative treatment is appropriate for patients with a recent diagnosis, including asymptomatic or oligosymptomatic patients. The use of insoles, orthoses, shoe modifications, physical therapy, muscle strengthening and somatosensory training is the basis of this therapy, which results in a satisfactory outcome in a significant proportion of cases. This treatment aims to accommodate the deformity using protective devices, preserve some degree of foot soft tissue flexibility, avoid exaggerated retraction of the structures that determine the deformity and better control the position and stabilization of the foot during walking[6-8].

Surgical treatment is indicated for static or dynamic foot deformities in patients with symptoms that are refractory to clinical treatment and compromise quality of life. The primary objective of surgical treatment is to achieve a painless, stable, plantigrade foot that is adaptable to the use of footwear; secondary objectives include preservation of joint mobility and muscle strength wherever possible. Soft tissue procedures include tendon stretching, shortening or transfer, release of contracted structures (capsulotomies or plantar fasciotomy) and ligament reconstruction in unstable joints. Osteoarticular deformities are treated with position correcting osteotomies to restore a proper alignment axis; these osteotomies can be performed on virtually all the bones that constitute the foot. In cases with very severe deformities, irreparable loss of muscle strength that balances foot alignment, advanced joint stiffness or severe arthrosis, arthrodesis is a safe option to resolve the clinical condition and also serves as a salvage procedure in cases of previous surgical failure[1,9].

Osteotomy with elevation of the first ray is a common surgical procedure that provides satisfactory results for the cavovarus foot. Elevation of the first metatarsal is achieved through two bone surgical sections in the proximal region of the first metatarsal that meet on the plantar side of the bone, creating a dorsal base wedge. Removal of this bone wedge exposes the two surgical section surfaces, which are connected and closed by an extension manoeuvre of the first metatarsal, leading to the expected correction. Fixation of this osteotomy can be performed with a Kirschner

wire, transosseous cerclage with a steel wire, screw-anchored cerclage or a screw, clamp or plate. Mechanical complications associated with this procedure include difficulty in fixating the osteotomy due to the small amount of bone remaining in the proximal region of the first metatarsal, delayed discharge for walking due to the creation of an osteotomy tract that is located with the load axis at the shear plane, excessive metatarsal elevation even with resection of small wedges and discomfort caused by the synthesis material in the dorsal region[1,6,9,10-12].

The modified technique performed for elevation of the first ray is based on modification of the bone surgical section axis to a 45º oblique angle relative to the joint between the medial cuneiform and the first metatarsal, which was proposed by Barouk, Rippstein and Toullec[13,14]. This modification allows greater proximal space to insert a screw, transforms the shear forces of the original osteotomy into compressive forces to provide safe loading and allows fixation with a single screw perpendicular to the osteotomy axis[13].

The aim of the present study was to describe the preliminary results of the proposed surgical technique and to evaluate pre-, intra- and postoperative radiographic images three and six months after the procedure in patients who underwent surgical treatment of cavovarus foot in which oblique proximal osteotomy of the first metatarsal was performed for dorsal wedge resection.

METHODS

This study was approved by the Ethics Committee with registration in the Brazil Platform under CAAE number: 73409317.0.0000.0068.

This is a series of five clinical cases of patients who underwent modified osteotomy with elevation of the first metatarsal in 2017.

The following outcomes were evaluated: consolidation or non-consolidation of the osteotomy, consolidation time, loosening and/or breaking of the synthesis material and the degree of correction achieved.

The osteotomy technique is based on a dorsomedial approach to the proximal region of the first metatarsal; a bone surgical section is performed immediately distal to the plantar joint between the first cuneiform and the base of the first metatarsal, 45º oblique relative to this joint surface. Next, a new osteotomy is performed such that three millimetres of the dorsal cortex of the first metatarsal are excluded; this osteotomy meets the first bone surgical section in the plantar region of the first metatarsal. A dorsal base bone wedge is designed, which is then excised. The two segments of the first metatarsal, the proximal and the distal segments, are brought together with a plantar pressure manoeuvre in the first metatarsal head, the two osteotomies meet, the dorsal wedge is closed, and the flexion of the first metatarsal and consequently the cavus is corrected. The osteotomy is fixed with a cortical screw (2.4, 2.7 or 3.5 mm, depending on the size of the patient's bone) inserted at the base of the first metatarsal, implanted from dorsal to plantar, from proximal to distal, perpendicular to the osteotomy. Correct execution of the procedure is confirmed by radioscopic control.

The preoperative evaluation is shown in Figures 1 and 2.

Osteotomy and fixation are shown in Figure 3.

The immediate postoperative evaluation is shown in Figures 4 and 5.

RESULTS

The evaluation included analysis of the pre-, intra- and postoperative radiographic characteristics of the patients together with their epidemiological variables.

Figure 1. Preoperative clinical pictures.
Source: Authors' personal archive.

Of the total number of patients included in the study, three had a cavovarus foot deformity due to Charcot-Marie-Tooth disease, one patient had congenital clubfoot sequelae, and one patient had polio sequelae (Table 1).

Figure 2. Preoperative radiographs.
Source: Authors' personal archive.

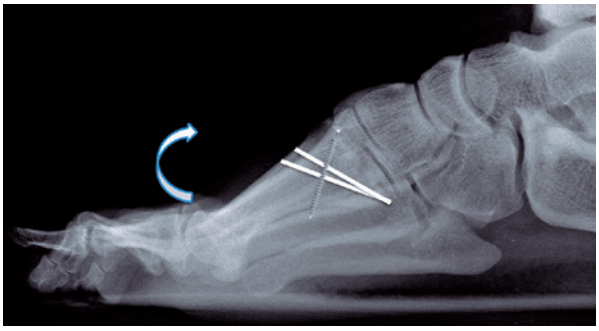

Figure 3. Demonstration of the surgical sections and fixation of the osteotomy.
Source: Authors' personal archive.

Figure 4. Postoperative radiograph at the 6-month follow-up.
Source: Authors' personal archive.

In the radiographic analysis, all cases showed signs of full osteotomy consolidation, without any breaking or loosening of the material.

DISCUSSION

Oblique osteotomy with elevation of the first metatarsal to correct a cavovarus foot deformity aims to overcome the primary difficulties encountered in the intraoperative period and during patient follow-up in the postoperative period. Modification of the bone surgical section axis to a 45º oblique angle relative to the axis of the medial wedge-first metatarsal joint allows better visualization and a safer working space to insert the osteotomy fixation screw and modifies the biomechanics during walking, transforming the resulting force generated by the obliquity of the bone surgical section into compression strength[13].

The main complications inherent to the first metatarsal osteotomy procedure are postoperative infection, recurrence of the deformity, residual pain and non-union of the osteotomy. Synthesis material complications, such as breaking and loosening, are less frequent.

With the modified osteotomy, no cases of non-union were identified after the procedure during the patient

Figure 5. Immediate postoperative clinical picture.
Source: Authors' personal archive.

Table 1. Primary pathologies of cavovarus foot patients subjected to modified osteotomy of the first metatarsal

Age	Gender	Diagnosis	Side
50 y	F	Charcot-Marie-Tooth	L
54 y	F	Poliomyelitis sequelae	L
28 y	M	Charcot-Marie-Tooth	L
27 y	F	Congenital clubfoot sequelae	L
27 a	F	Charcot-Marie-Tooth	L

Source: Prepared by the author based on the results of the study.

follow-up. This finding is important considering that other cases reported in the literature show variable rates of 3.6% to 18.2% depending on the technique and material used for osteotomy fixation. The postoperative infection rate was zero, with all surgeries performed in the same hospital environment[15].

Regarding failure of the synthesis material, no alterations indicative of failure or breakage of the osteotomy fixation material were observed. The oblique bone surgical section performed at the base of the first metatarsal increases the transmission of forces during walking to the osteotomy interface, decreasing the stress on the fixation screw and consequently reducing synthesis material failure rates.

CONCLUSION

The present study demonstrated the efficacy of the modified osteotomy technique based on radiographic alterations and outcomes, as it resulted in reduced complication rates associated with the surgical procedure and correction of the cavovarus foot deformity with main involvement of the forefoot. Functional studies will be conducted in the future to determine other outcomes of this surgical technique.

Authors' contribution: Each author contributed individually and significantly to the development of this article: DKM *(https://orcid.org/0000-0002-7281-2054) wrote the article, interpreted the study results; RTO *(https://orcid.org/0000-0001-7742-829X) conceived and planned the activities that led to the study, participated in the review process and approved the final version; TPS *(https://orcid.org/0000-0002-4690-4457) interpreted the study results; RBS *(https://orcid.org/0000-0003-1085-0917) participated in the review process and approved the final version; RSM *(https://orcid.org/000-0002-5025-4338) wrote the manuscript, interpreted the study results and approved the final version; TDF *(https://orcid.org/0000-0002-9687-7143) participated in the review process and approved the final version. *ORCID (Open Researcher and ontributor ID).

REFERENCES

1. Maranho DAC, Volpon JB. Pé cavo adquirido na doença de Charcot-Marie-Tooth. Rev Bras Ortop. 2009; 44(6):479-86.
2. Guyton GP, Mann RA. Pes cavus. In: Coughlin MJ, Mann RA, Saltzman C. Surgery of the foot and ankle. Philadelphia: Mosby; 2007. p. 1125-48.
3. Aminian A, Sangeorzan BJ. The anatomy of cavus foot deformity. Foot Ankle Clin. 2008;13(2):191-8.
4. Beals TC, Nickisch F. Charcot-Marie-Tooth disease and the cavovarus foot. Foot Ankle Clin. 2008;13(2):259-74.
5. Mann DC, Hsu JD. Triple arthrodesis in the treatment of fixed cavovarus deformity in adolescent patients with Charcot-Marie-Tooth Disease. Foot Ankle. 1992;13(1):1-6.
6. Sammarco GJ, Taylor R. Combined calcaneal and metatarsal osteotomies for the treatment of cavus foot. Foot Ankle Clin. 2001; 6(3):533-43.
7. Fortin PT, Guettler J, Manoli A 2nd. Idiopathic cavovarus and lateral ankle instability: recognition and treatment implications relating to ankle arthritis. Foot Ankle Int. 2002;23(11):1031-7.
8. Faldini C, Traina F, Nanni M, Mazzotti A, Calamelli C, Fabbri D, Pungetti C, Giannini S. Surgical treatment of cavus foot in Charcot-Marie-Tooth Disease: a review of twenty-four cases. J Bone Joint Surg Am. 2015;97(6):e30.
9. Sammarco GJ, Taylor R. Cavovarus foot treated with combined calcaneus and metatarsal osteotomies. Foot Ankle Int. 2001;22(1):19-30.
10. Grice JE, Willmott HT, Heath P. An algorithm to assist the surgical decision making in the operative management of the cavovarus foot. Foot & Ankle Orthopaedics. 2016;1(1).
11. Yoo Jung Park MD, Kwang Hwan Park MD PhD Yeokgu Hwang MD, Dong-Woo Shim MD, Seung Hwan Han, et al. Treatment outcomes of chronic lateral ankle instability associated with mild cavovarus deformity. Foot & Ankle Orthopaedics. 2016;1(1).
12. de Palma L, Colonna E, Travasi M. The modified Jones procedure for pes cavovarus with claw hallux. J Foot Ankle Surg. 1997;36(4):279-83.
13. Toullec E, Barouk LS, Rippstein P. Ostéotomie de relèvement basal Métatarsien BRT. In: Valtin B, Leemrijse T (coord.). Chirurgie de l'avant Pied. Paris: Elsevier, Paris; 2007. p. 142-48.
14. Barouk LS. Forefoot reconstruction. 2ed. Paris: Springer-Verlag Paris; 2005. Chap 3: The BRT Proximal Metatarsal Osteotomy. p. 139-54.
15. Lavery LA, Peterson JD, Pollack R, Higgins KR. Risk of complications of first metatarsal head osteotomies with biodegradable pin fixation: Biofix versus Orthosorb. J Foot Ankle Surg. 1994;33(4):334-40.