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ORIGINAL ARTICLE

Pseudoarthrosis after distal percutaneous osteotomy of lower distal radii ☆

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KEYWORDS
Pseudoartrosis;
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Abstract
Objective: The introduction of the minimally invasive surgery allows the surgical correction of the foot through small incisions, minimizing the surgical exposure, the aggression to the soft tissues, and improving surgical efficiency. But in spite of its good results, it is not exempt from possible complications.
Material and methods: We report two patients treated for metatarsalgia with minimally invasive surgery, who six months after the initial surgery had to be re-operated due to pain and absence of consolidation of the distal metatarsal osteotomies. Both cases were treated by means of curettage of the area of pseudoarthrosis, open reduction, internal fixation and bone grafting. The surgery showed the presence of a great quantity of fibrous tissue adjacent to the different areas of pseudoarthrosis, which could be related to the high temperatures generated by the procedure and which had a total effect on the adjacent soft tissues.
Results: The exact point of the distal metatarsal osteotomies or the effects of the increase of the temperature during the procedure might be related to the appearance of the pseudoarthrosis.
Conclusion: Minimally invasive surgery of the forefoot has led to solving some of the problems found with open procedures. Nevertheless its generalization can give rise to other complications that up until now were more difficult to find. Therefore knowledge of their appearance will enable those to be aware of them and for those that it is necessary to be aware of, put all the means to avoid them, and inform the patient of their.

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PALABRAS CLAVE
Pseudoartrosis;
Osteotomía distal percutánea

Pseudoartrosis tras osteotomía distal percutánea de los radios menores

Resumen
Objetivo: La introducción de la cirugía percutánea ha permitido la corrección quirúrgica del pie a través de pequeñas incisiones, minimizando así la exposición quirúrgica, la agresión de los tejidos blandos y rentabilizando el tiempo quirúrgico. Pero a pesar de sus buenos resultados, no está exenta de posibles complicaciones.
Material y método: Presentamos dos pacientes intervenidos por metatarsalgia mediante abordaje percutáneo, que tuvieron que ser reintervenidos por presentar dolor y ausencia de consolidación de las osteotomías distales de los metatarsianos a los seis meses de la cirugía inicial. Ambos casos fueron tratados mediante reducción abierta y síntesis mediante placa atornillada, tras realizar curetaje del foco de pseudoartrosis y aporte de injerto óseo.
Resultados: La cirugía puso en evidencia la presencia de una gran cantidad de tejido fibroso adyacente a los distintos focos de pseudoartrosis, que podría estar relacionada con las altas temperaturas generadas por el fresado óseo y que repercuten en su totalidad sobre los tejidos blandos adyacentes. El punto exacto de la realización de las osteotomías distales de los metatarsianos o los efectos del incremento de la temperatura durante el fresado óseo podrían estar relacionados con la aparición de la pseudoartrosis de las osteotomías.
Conclusiones: La cirugía mínimamente invasiva del antepie ha venido a solucionar algunos de los problemas encontrados mediante "técnicas abiertas". Sin embargo, su generalización puede plantear la aparición de otras complicaciones que hasta la fecha eran más difíciles de encontrar y para las que se necesita saber de su posible aparición para poder poner todos los medios para evitarlas, e informar al paciente de su existencia.

Introduction

Metatarsalgia is the most common location of pain in the foot. Initially pain appears with weight-bearing but, as the problem continues, some patients may even have pain while at rest due to the chronic inflammation of all the tissues making up the central support of the forefoot. Failure of conservative treatment measures indicate the need for surgical treatment.[1-4]

The percutaneous technique used for surgical correction of metatarsalgia consists in performing a distal osteotomy of the metatarsals of the lower radii[5,6] in an attempt to shorten and elevate the head of the metatarsals.[4] Percutaneous surgery of the forefoot has introduced certain advantages into the surgical correction of the foot; however, despite the good results it achieves, it is not free from possible complications.

We present the cases of two patients who underwent percutaneous surgery for metatarsalgia and who had to undergo subsequent surgery due to pain and failure of the distal osteotomies of the metatarsals to consolidate six months after the initial surgery.

Case 1

Our first case is a 49-year old female, with no personal history of interest, who was operated on for *hallux valgus* and metatarsalgia of the second radius by means of percutaneous surgery with fluoroscopic guidance; an exostectomy was performed, as was a tenotomy of the adductor tendon of the first toe and osteotomy of the base of the first phalanx of the hallux using Akin's technique. A percutaneous distal osteotomy was performed on the second metatarsal.

Following an initially uneventful post-operative period, the patient reported persistence of her metatarsalgia at the three- and four-month check-ups. The successive post-operative radiological controls reveal favourable evolution of the surgery performed for the *hallux valgus*; nevertheless, they also reveal poor alignment and the consequent delayed consolidation of the osteotomy of the second metatarsal, confirming pseudoarthrosis six months following the procedure.

Seven months after the initial procedure, the patient underwent revision surgery by means of a dorsal approach to the second metatarsal of the right foot to clean and curettage the focus of pseudoarthrosis. The posterior reduction and osteosynthesis was achieved by placing a screw plate laterally, with the addition of autologous graft taken from the proximal tibia at the site of the focus.

The rescue surgery evolved favourably; the metatarsalgia remitted and consolidation of the osteotomy was achieved (figs. 1a and 1b).

Case 2

Fifty-two year old female, with a history of early menopause after gynaecological surgery, underwent percutaneous surgery due to painful *hallux valgus*, in addition to metatarsalgia of the central radii and painful varus fifth toe of the foot right.

The *hallux valgus* and metatarsalgia of the central radii were corrected by means of the previously described percutaneous approach. A distal oblique osteotomy was chosen to correct the varus of the fifth toe.

The persistence symptoms in the area of the central radii and the varus of the fifth toe, in addition to the postoperative

Figure 1 Case 1. A) Delayed consolidation of the osteotomy of the second metatarsal, confirming pseudoarthrosis six months after the intervention. B) Cleaning and curettage of the focus of pseudoarthrosis, reduction and osteosynthesis by means of a laterally placed screw plate, adding autologous graft taken from the proximal tibia at the site of the focus. The rescue surgery evolved without incident; the metatarsalgia remitted and consolidation of the osteotomy was achieved.

radiological controls revealed that the osteotomies were evolving towards pseudoarthrosis. Six months after surgery, the patient once again underwent surgery by means of a dorsal approach to the forefoot, curettage of the focus of pseudoarthrosis, reduction and osteosynthesis with a dorsally placed screw plate in the case of the second and fourth radii (after *in vivo* verification of spontaneous consolidation of the third radius), and a compression screw for the fifth radius. Osteosynthesis was supplemented with the osteoinductive allograft Opteform® RT (MBA Spain), at the site of the foci of the pseudoarthrosis that had undergone surgical intervention.

Evolution following the second procedure was favourable, with remission of the symptomatology of the forefoot and radiological consolidation of the osteotomies (figs. 2a and 2b).

Discussion

The presence of articular stiffness, "floating toe" deformity, persistence of symptomatic plantar hyperkeratosis, transfer metatarsalgia and pseudoarthrosis, are some of the complications documented following a Weil osteotomy.[2,4,7-10]

The introduction of percutaneous surgery has enabled surgical correction of the foot to be carried out through small incisions, thereby minimizing the exposed surgical field and aggression to soft tissues, while making the most of the surgical time involved.[4-6] However, its generalization can bring about the appearance of other complications that until now were more difficult to find.

Figure 2 Case 2. A) Persistence of symptomatology, as well as the radiological controls, revealed that the osteotomies were evolving toward pseudoarthrosis. B) Dorsal approach to the forefoot, curettage of the focus of pseudoarthrosis, reduction and osteosynthesis with a dorsally placed screw plate (intra-operative verification of consolidation of the third radius) and a compression screw for the fifth radius. Osteosynthesis was supplemented with the osteoinductive allograft Opteform® RT (MBA Spain). Evolution following the second procedure was favourable, with remission of the symptomatology of the forefoot and radiological consolidation of the osteotomies.

The exact point at which distal osteotomies of the metatarsals are performed or the effects of the increased temperature during bone drilling may have to do with the appearance of complications.[4-6,11-13]

It is well-known that the exposure of bone to excessive increases in temperature during drilling can lead to thermal necrosis of the bone. Temperatures above 50°C for 60 seconds cause irreversible changes in the structure and physical properties of the bone such as degeneration of the osteocytes, increased osteoclastic activity and the appearance of both bone fibrosis and necrosis.[11-13] The use of drills in poor operating condition or at inappropriate speeds causes the temperature to rise and/or prolonged drilling time that brings about local alterations and can lead to the appearance of a delay in consolidation and pseudoarthrosis. In the two cases presented here, the tremendous amount of fibrosis adjacent to the various foci of pseudoarthrosis encountered during surgery was particularly striking; this fibrosis might be related to the high temperatures generated by the bone drilling and their overall impact on the adjacent soft tissues. In a study published by Piqué Vidal[11] in 2005 regarding the effect of temperature elevation during drilling in the percutaneous treatment of *hallux valgus*, the authors report that the higher the temperature reached by the drill during osteotomies, the greater the increase in the thickness of the foot in the area operated on.

The design of the percutaneous distal osteotomy pursues a controlled elevation of the metatarsal heads consistent with both the position of the heads of the metatarsals in the sagittal plane,[4,5] as well as the metatarsal formula. The precise point is the cervical-diaphyseal junction in an oblique slice at an approximate 45° angle. The advantage of this percutaneous osteotomy is that it causes very little metatarso-phalangeal stiffness, given that it is an extraarticular osteotomy.[4] The disadvantage is that it takes longer to consolidate. Ordinarily, consolidation can be expected to take up to 3 months.[4]

Precision when choosing the exact point at which to make the osteotomies is a key factor in the consolidation and final alignment of the metatarsal heads and when it comes to avoiding delayed consolidation and malunion.

The Helal osteotomy is an open, oblique, dorsal diaphyseal osteotomy of the metatarsals; it became quite popular around the middle of the seventies for the surgical treatment of metatarsalgia. It has fallen into disuse nowadays as a result of the high rate of pseudoarthrosis published in the literature in relation to its location, more proximal in the metatarsal in comparison with the (more distal) Weil osteotomy which entails a much lower incidence of pseudoarthrosis.[9,14]

In the two cases we have reported here, the osteotomies are performed proximal to the cervical-diaphyseal junction, between 3 and 15 mm away. The misplacement of the osteotomies performed, in some cases diaphyseal and, hence, more proximal than described in the original surgical technique, may in fact be the fundamental cause of the appearance of pseudoarthrosis, similar to what happens in the Helal osteotomy.

The distal percutaneous osteotomy of the metatarsals must be properly planned, studying the metatarsal formula in the X-rays taken with weight-bearing, as well as clinically. Pseudoarthrosis is not a common finding and is usually the result of insufficient apposition of the fragments. The precise point of osteotomy, since the problem might appear when the osteotomy is performed on the diaphysis, as in the open Helal osteotomy, or the effects of increased temperature may be inter-related.

Level of evidence

Clinical case study. Level of evidence V.

Conflict of interest

The authors state that they have no conflict of interest.

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