Metatarsal osteotomies in *Hallux Rigidus*

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Abstract

This work presents the objectives and indications of the three distal osteotomies of the first metatarsal most frequently used in *Hallux Rigidus* surgery: Weil-Barouk oblique osteotomy, Youngswick (modified Chevron) osteotomy, and Watermann dorsal closed wedge osteotomy. The surgical technique, indications, advantages, and disadvantages of each of them are described.

Level of Evidence V; Therapeutic Studies; Expert Opinion.

**Keywords:** *Hallux rigidus*; Osteotomy; Metatarsal bones; Forefoot, human.

Introduction

The aim of osteotomies is achieving a more mobile and pain free joint, correcting the etiopathogenic factors that caused the deformity. Osteotomy is intended: 1) To decompress the joint. 2) To shorten the first metatarsal in cases of index-plus metatarsal formula or to decompress the joint. 3) To realign the joint. 4) To lower the first metatarsal head to correct *metatarsus primus elevatus* and *Hallux Flexus*, thus reestablishing the rotation center of metatarsal head. 5) To relax muscles and plantar fascia, which are often retracted. 6) To reduce intermetatarsal angle in cases of *Hallux Valgus-Rigidus*.

Indications

According to Coughlin and Shurnas classification⁵, osteotomies are indicated in advanced grade II and in early grade III with joint surface involvement lower than 50%. Both distal oblique osteotomy, as described by Weil for lateral rays and popularized by Barouk⁶, and Youngswick osteotomy⁷ shorten the metatarsal, decompress the joint, lower the first metatarsal head, and relax muscles and fascia plantar. Therefore, they are indicated for most cases of *Hallux Rigidus* in which the first metatarsal is long or elevated (*metatarsus primus elevatus*), and in the presence of *Hallux Flexus* associated with plantar fascia retraction. In cases of index-plus-minus metatarsal formula, shortening caused by osteotomy in the horizontal plane is compensated with lowering of metatarsal head in the frontal plane. Watermann osteotomy⁸ is indicated in cases of *Hallux Rigidus* with no *metatarsus primus elevatus*, *Hallux Flexus*, or plantar fascia retraction. This type of osteotomy realigns articular surface without shortening the metatarsal or lowering its head.

Surgical Techniques

A. Distal oblique osteotomy

This osteotomy is widely used in the treatment of *Hallux Rigidus* (Figure 1).

A medial incision centered on the first metatarsophalangeal joint (MTPJ) was performed. Subsequently, the joint was subluxated in order to allow for surgeons to operate on it. Oblique osteotomy of the metatarsal head was conducted from the dorsal-distal to the plantar-proximal direction, starting on the articular surface with chondral lesion, with an angle from 35° to 45°, based on the extent to which metatarsal head should be lowered. Osteotomy was finished on the plantar surface, proximal to the entry of the vascular bundle that irrigated the metatarsal head, in order to prevent its necrosis. Subsequently, the first metatarsal head was subjected to proximal plantar displacement, depending on the length of the first metatarsal and its degree of dorsiflexion. In our experiment, displacement was +/- 5mm. Osteosynthesis was performed with two double-threaded cannulated screws measuring 3mm in diameter, paying attention to their location so...
that it did not surpass the articular surface. Two screws were used in order to prevent varus-valgus displacements of the first metatarsal head. Finally, the excess or dorsal roof and medial exostosis were resected. Sometimes, if fascial tension persists, we recommend performing a proximal percutaneous plantar fasciotomy. In Egyptian feet, which have a very long hallux, we recommend shortening the proximal phalanx, thus reducing axial pressure resulting from contact between shoes and the distal end of the toe.

In cases of Hallux Valgus-Rigidus, this technique allows for act on both deformities.

**B. Youngswick (or modified Chevron) osteotomy**

This technique was described by Youngswick(3) in 1982 as a modification of the Austin osteotomy. It is also one of the distal metatarsal osteotomies most widely indicated for Hallux Rigidus (Figure 2).

Using the same approach of the previous technique, a V-shape osteotomy was performed with a slightly dorsal vertex on the metatarsal head and the two diagonal lines directed from dorsal-proximal to plantar-proximal towards the vertex, forming an angle of 60°. Subsequently, a second osteotomy was performed parallel to the dorsal branch of the first osteotomy. The width of this second osteotomy determines shortening and lowering of the first metatarsal and articular decompression. This osteotomy is intrinsically more stable than the previous one; thus, only one screw is required for osteosynthesis. This procedure can also be used in cases of Hallux Valgus-Rigidus.

**C. Watermann dorsal closed wedge osteotomy**

Watermann(4) described this procedure in 1927 as a trapezoidal dorsal closed wedge osteotomy on the first metatarsal neck (Figure 3).

Using the same approach as the previous techniques, dorsal wedge osteotomy is performed on the metatarsal head. When osteotomy is closed by dorsiflexion, the metatarsal head rotates so that the plantar articular cartilage, which is usually healthy, is the segment that comes into contact with the base of the phalanx. Furthermore, this procedure reduces the volumetric content of the first MTPJ. This is a relatively unstable osteotomy, due to its perpendicular direction, and has difficult osteosynthesis.

**Results**

Currently, most authors(5,6) agree that osteotomies are successful in Hallux Rigidus grades I and II, whereas results are more unpredictable in the most advanced phases of disease. We share this view.
The published literature on distal oblique osteotomy is heterogeneous: authors use different classification methods, indicate surgery in different grades of Hallux Rigidus (from grade I to III), although it has never been indicated for grade IV, and follow-up time after intervention varies widely: from 12 months up to 11.1 years. However, all authors do agree on the goodness of the technique, with rates of excellent and good outcomes higher than 80%.

Our experiment with distal oblique osteotomy is based on 32 feet, all presenting with grade II of the disease, with a mid-term follow-up of 39.4 months. Results were consistent with those of the reviewed literature: outcomes were excellent in 75% of the cases, and good in 25%, which is explained by the fact that our series did not include patients in advanced disease phases.

Kilmartin compared oblique osteotomy with Reverdin-Green osteotomy and shortening Scarf osteotomy and did not find differences in results as well.

A literature review on Youngswick osteotomy showed similar findings: series were little homogeneous. Dickerson et al. observed 94% of satisfactory outcomes with 32 patients, with a mid-term follow-up of 4 years. Slullitel et al. also found satisfactory long-term outcomes in 61 operated patients with Hallux Rigidus of grades II and III. Olof and Jhala-Patel indicate osteotomy in grades III and IV of the disease and obtained a satisfaction level of 85% among their patients.

Since distal oblique osteotomy and Youngswick osteotomy have the same objectives and indications, several comparative studies have been conducted to assess whether one technique is better than the other.

We published a prospective study of both osteotomies in the mid-term, with a minimum postoperative time of 24 months. Twenty-five feet operated with each technique were evaluated, all presenting with grade II of the disease, and there were no significant differences in outcomes. Xu et al. also compared the results of the two osteotomies in 33 feet. In their case, intervention was indicated in grades III and IV of the disease. They did not find differences between the two techniques as well. Interestingly, a study by LaMar et al. performed a mechanical comparison with bone models in a laboratory, in order to assess the stability of the two osteotomies. There was likewise no difference between them.

With regard to distal Watermann dorsiflexion osteotomy, Cho et al. reviewed 42 feet with a mid- to long-term follow-up of at least 3 years, in patients with Hallux Rigidus of grades III and IV. Based on the results, the authors conclude that this osteotomy is effective in grade III with viable cartilage on at least 50% of the articular surface, but should not be indicated in grade IV, due to the high rate of reoperations. Laakmann et al. have modified osteotomy by adding a double section in the dorsal line in order to realign the metatarsal head in dorsiflexion and lower it in the frontal plane. This makes it possible to correct metatarsus primus elevatus-Hallux Flexus and to relax the plantar fascia, achieving good results.

Lee et al. compared the outcomes of distal oblique osteotomy with those of cheilectomy and concluded that, although the latter technique has a recurrence rate of 30%, which is explained by the fact that it does not resolve the etiopathic-genic factors causing Hallux Rigidus, the two techniques gave satisfactory outcomes for the patient.

Complications
The complications described with these techniques are the following:
1. Delayed union, malunion, or non-union
2. Avascular necrosis of the metatarsal head
3. Osteotomy fracture
4. Hardware loosening
5. Transfer metatarsalgia
7. Disease recurrence.

Conclusions
According to the published literature and to our own experiment, we consider that osteotomies are indicated in the treatment of grade II and early grade III Hallux Rigidus. Their purpose is to preserve articular surface, decompress the joint, and correct changes in the center of rotation.

Although disease origin is multifactorial, we believe that excessive plantar fascia tension is a determining factor for metatarsus primus elevatus and Hallux Flexus. In selected cases, plantar fasciotomy on the heel allows for additional joint decompression.

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