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Review Article

Hallux Rigidus: A Literature Review of Classifications, Etiology and Treatment

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Abstract

The Hallux rigidus is a condition characterized by a progressive degenerative process for the hallux's 1st metatarsophalangeal joint. After hallux valgus, hallux rigidus is he second pathology on a frequency order affecting the hallux and it is the most common arthritic pathology for the foot.

Notwithstanding the large amount of documentation available in regard to this phenomenon, a definitive treatment algorithm still has not been retrieved. Therefore, it is still under debate. The medical literature supports the joints' fusion as a technique having the most predictive and reproducible effect and satisfying results. However, multiple surgery alternatives that can delay or prevent the sacrifice of the joints' movement are attested. The ideal treatment purpose should be the complete restoration of the foot's normal functionality through the elimination of the pain, a good alignment and cosmetics and consequently, significantly improving patients' quality of life, on either a medium or long term, pre-admonishing however the probability of future treatments in case the first could not be resolute.

Keywords: *Hallux Rigidus; Etiology; Treatment*

Introduction

The Hallux rigidus is a condition characterized by a progressive degenerative process for the hallux's 1st metatarsophalangeal joint. Following hallux valgus, hallux rigidus is the second pathology on a frequency order affecting the hallux [1-3]. It is more frequent in women on a ratio of 2:1; a certain familiarity with the phenomenon is reported [4]. On a large scale, the disease manifests itself in a unilateral way, but a development of bilateralism can reach the 80% of the cases 9 years after the first manifestation [5].

The first description of hallux rigidus as pathology dates back to 1887 by Davies Colley, who defined it as hallux flexus. Cotterill coined the term hallux rigidus a few years later; who defined it as a painful range of motion limitation of the 1st metatarsophalangeal joint [6-9].

Notwithstanding the large amount of literature available in regard to this phenomenon, a definitive treatment algorithm still has not been retrieved. The literature supports joint fusion as a technique having the most predictive and reproducible and satisfying results. However, multiple surgery alternatives that can delay or prevent the sacrifice of the joints' movement are reported. The goal should be the complete restoration of the foot's normal functionality through the elimination of pain, a good alignment and cosmetics and consequently, improving significantly patients' quality of life, on either a medium or long term, pre-admonishing however the possibility of future treatment in case of failure of the first procedure [10].

Clinical diagnosis

Patients report pain, difficulty in wearing shoes and stiffness of the first ray. The pain prevails during the push off gait phase [11]. During the initial stages, the pain is concentrated in the metatarsal phalangeal joint, especially in dorsiflexion, whereas it is minimal at the movement's intermediate arch. The pain during the plantar flexion can be due to the conflict between the soft tissues and the dorsal osteophytes. The absence of pain during the mid-range of motion is defined negative "grind test", because there is probable cartilage integrity in the central and plantar aspect of the metatarsophalangeal joint [12]. The presence of a negative grind test is pivotal for surgical decision-making.

Etiopathogenesis: classification and description

In order to promptly classify the hallux rigidus and to consequently apply the most suitable surgical procedures, an evaluation of the causes that lead to the development of the phenomenon is necessary. The foot and ankle surgeon should be able to determine whether a specific cause is present to elaborate the best surgical option [13].

Nevertheless, the examination of the causes allows the surgeon to figure out the best surgical and non-surgical opportunities. These causes can be grouped in:

Bio-mechanical causes:

a. Excessive length of the 1st metatarsus
b. Hypermobility of the first ray
c. Elevation of the 1st metatarsus
d. First metatarsus head geometry
e. Metatarsus adductus and interphalangeal hallux valgus.

Non/biomechanical causes:

a. Traumatic causes
b. Metabolic causes
c. Neuromuscular causes
d. Rheumatic causes
e. Congenital causes
f. Iatrogenic causes.

Biomechanical causes

Excessive length of the 1st metatarsus

A 1st excessively long metatarsus is described by Root., *et al*. [14] as a possible cause of hallux rigidus. Nilsonne [15] postulated that a long 1st metatarsus reduces the plantar flexion and increases the compression of the 1st metatarsophalangeal joint.

Beeson and collaborators [16] reported that in patients affected by hallux rigidus the first metatarsus was longer in respect to the medium length ratio; for a 37% of the cases in respect to the 2nd metatarsus, whereas for a 75% of the cases in respect to the 3rd metatarsus. Munera and collaborators identified a trend of length for the 1st metatarsus [17] but not statistically significant.

Hypermobility of the 1st ray and elevation of the 1st metatarsus

Root identified among the multiple causes a hypermobility of the 1st ray [14]. As a consequence of a foot eversion due to an abnormal pronation of the subtalar joint the lateral column becomes unstable during the mid-stance and the following propulsive phases of the

step, losing the physiological and functional block for the mid foot and rearfoot, so depriving the long peroneal tendon of its plantar flexing strength on the 1st ray. As a consequence, a functional limitation of the hallux's dorsal flexion can appear due to the fact that the 1st metatarsus dorsalises and inverts, losing the mechanical advantage of the plantar flexion for the first ray. Lambrinudi illustrated the concept of metatarsus primus elevatus the first time in 1938 [18], based on a single patient. He observed an unstable gait and an elevated medial column. The case was surgically treated correcting the elevation of the first metatarsal bone through the successful plantar flexion of the first ray. On the base of this case the author cites among the causes of hallux rigidus/limitus the elevation of the 1st metatarsus.

Later even Root [14] describes the elevation of the 1st metatarsus among the causes of hallux rigidus/limitus. But not all the experts share with this theoretical approach. Coughlin and Shurnas [19] report that it is probable that the elevation of the 1st metatarsus could be a consequence of the arthritic degeneration of the 1st metatarsophalangeal joint.

Meyer [20] reported that 8 mm elevation of the 1st metatarsus in respect to the second on the weight bearing lateral x-ray image is a common observation in the normal, as the one of a foot affected by hallux rigidus.

Nevertheless, in a recent research published by Vulcano and Myerson, it is attested, through TC evaluation, the presence of an elevatus of the 1st metatarsus during the advanced phases of hallux rigidus [21].

Maceira and Monteagudo [22] go in deep with the concept of functional biomechanical hallux rigidus, which is directly connected with the elevation of the first metatarsus. Such condition is defined as that clinical condition in which the movement of the 1st metatarsophalangeal joint is limited when the foot is in orthostasis, whereas it is free when the foot is out of load. The range of motion during weight bearing of the hallux metatarsophalangeal joint is controlled by structures which are more proximal to the metatarsophalangeal joint itself, among them the achilleus-plantaris complex and the medial column of the foot are the main responsible in providing the foot's medial support during the so called third rocket phase or propulsive phase.

To obtain this, a passive dorsiflexion of the first finger during the contact with the ground is necessary, while the 1st metatarsus that takes an upright position, lays on the hallux-sesamoid complex. In the event that the 1st metatarsus finds itself on a dorsiflexed position (elevation of the 1st metatarsus) or there is a tension increase at a plantar zone or functional limitation in the dorsiflexion of the ankle joint during the second rocket movement, then the passive dorsal flexion of the 1st metatarsus will be limited, losing the normal sliding mechanism of the hallux's metatarsophalangeal joint. As a consequence of this, there will be an overload on the dorsal area of the metatarsophalangeal joint with annexed joint limitation in dorsiflexion (Figure 1).

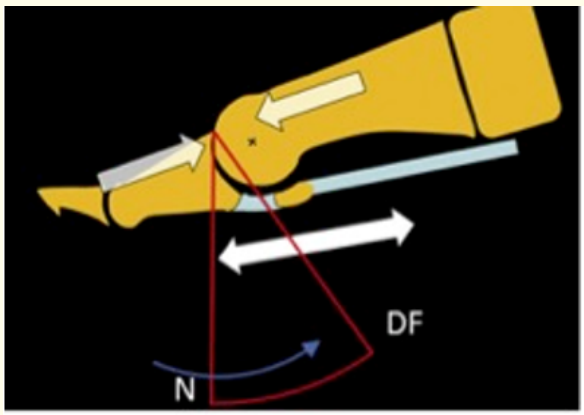

Figure 1: *The elevation of the 1st metatarsus or a contracture of the plantar fascia can determine a dorsal conflict between the first metatarsus and the phalanx [22].*

The authors affirm that a contraction of the elastic component of the gastrocnemius muscle when the knee is extended, during the intermediate gait phase, is the cause of a limitation to the dorsiflexion of the ankle joint and of the contracture of the plantar fascia. The authors conclude that whether the plantar fascia contracture is caused by the elevation of the 1st metatarsus, due to a mechanical anomaly, as previously mentioned, or due to a tension increase into the plantar fascia itself, the final effect is that there is an overloading in the dorsal part of the 1st metatarsophalangeal joint and so, a functional hallux rigidus.

Moreover, the authors describe the concept of biomechanical structural hallux rigidus as the final phase of the biomechanical functional hallux rigidus. Clinically, it manifests itself with a rigidity of the hallux both during weight bearing and non-weight bearing. From a practical point of view, both the two conditions can be distinguished through a simple test: the patient's foot is positioned with the ankle at 90 degrees simulating a load on the forefoot and the articulation of the 1st metatarsophalangeal joint is tested. Then, the foot is left on a relax position, out of load and the articulation of the hallux is re-tested. In case the rigidity only manifests itself on load, then a functional hallux rigidus can be spotted.

Maceira and Monteagudo report a test described by Samuel Barouk, which is the result of the clinical exam described above, but performed firstly with an extended knee, then with the knee flexed, imitating the Silfverskiold's test. In case that, with a flexed knee, functional hallux rigidus disappears, then the cause is to be attributed to the contraction of the gastrocnemius muscle, therefore recommending the performing of a gastroc release during surgery (Figure 2).

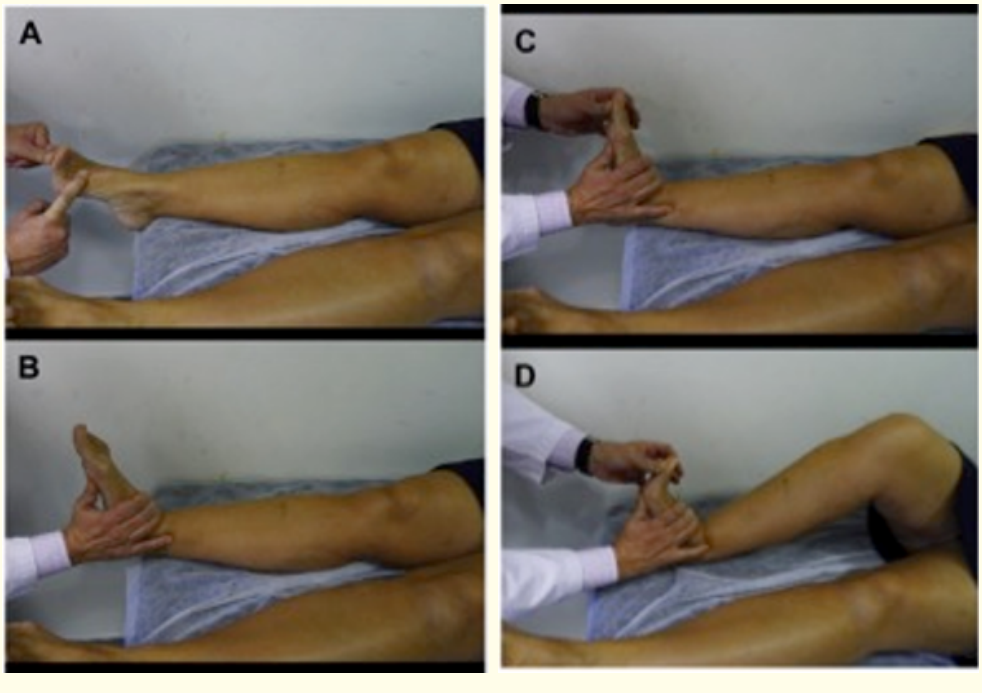

Figure 2: *Barouk's test for the evaluation of functional hallux rigidus [22].*

Geometry of the metatarsal head

Couglin and Shurnas on a radiographic study retrieve that a flat or a chevron type shape metatarsal head predisposes the patient to an increased risk to develop hallux rigidus.

Metatarsus adductus and interphalangeal hallux valgus

Coughlin and Shurnas [19] report a possible connection with metatarsus adductus and hallux rigidus; they affirm that a medial inclination of the forefoot can increase the pressure on the transverse surface of the medial part of the metatarsophalangeal joint,

increasing the risk of developing hallux rigidus. For an analogous mechanism is besides reported a connection with the interphalangeal hallux valgus.

Non-biomechanical causes

Within this group the injury to the joint is connected to a non-biomechanical source, that damages the metatarsophalangeal joint directly: trauma, metabolic disease, neuromuscular diseases, rheumatic diseases, congenital and iatrogenous anomalies.

Classification systems

Several classification methods are attested in order to examine and study the severity of the joint damage for the metatarsophalangeal joint [23,24]. Such systems' purpose is to help the surgeon choose the best treatment, operate significant comparisons between the pre and post-surgery phase and between the different treatment strategies [25]. An ideal classification should include criteria that clearly describe the different phases of the pathology, which must be easy and reproducible in their identification. In addition, besides guiding the therapeutic strategy, they must allow the delineation of the pathology's behavior and evolution as much accurately as possible (Figure 3). The published classifications illustrate separately or together the clinical and radiologic presentation of the arthritis of the 1st metatarsophalangeal joint.

Beeson and colleagues [16] evaluated several classification systems by examining their validity, trust ability, responsiveness and clinical usefulness (Figure 3) concluding that the system which is approaching to a gold standard for the most is the one proposed by Coughlin and Shurnas (Figure 4).

Studies	Strengths	Weaknesses
Kellgren & Lawrence[27]	Large sample size. Ordinal radiological criteria of OA. Independent testing & evaluation	Foot joints not included. IPJs of hand applied to MTPJ of foot. No clinical details.
Giannestras[18]	Concept that radiological features not always comparable to intra-op findings.	Brief information.
Drago et al.[13]	4th grade indicates total joint obliteration + loose bodies in joint/ capsule. First to present 'functional' grade hallux limitus.	Brief method. Compilation of classification not described. Applied system retrospectively to same sample used to develop it.
Hattrup & Johnson[23]	Combined appraisal of JSN, osteophytes & subchondral degeneration.	Only radiological criteria used based on fundamental changes to first MTPJ.
Karasick & Wapner[26]	Used MO view to demonstrate joint changes not seen on other views.	Insufficiently detailed radiological criteria.
Hanft et al.[22]	Progressive accumulation of radiological features. Grades 2 & 3 sub-categorized to include subchondral cysts.	No clinical information.
Schweitzer et al.[49]	MRI findings correlate well with plain X-rays.	No direct comparison of X-ray findings with MRI. Small sample.
Roukis et al.[46]	First grading system applied prospectively and to include 2nd MC joint OA.	Incorrect terminology describing osteophytes as exostosis. Biased selection of systems all with MPE.
Coughlin & Shurnas[11]	Time joint pain occurs during ROM. Includes best elements of prior systems. Subjective & objective clinical examination + x-ray data to determine grade. Grade-0 added to include asymptomatic patients with early loss of MTPJ motion.	Grades applied retrospectively to sample at final followup.
McMaster[39]	Mechanism of osteochondral defect	Brief radiological/clinical criteria. Only adolescence. Small sample.
Ronza et al.[47]	Table outlining HR clinical features.	Applied system retrospectively to same sample used to develop it.
Felson & Anderson[15]	Recommended applying devised system to separate sample.	Not specific to HR.
Regnauld[43]	Clear radiological parameters first MTPJ.	Fails to include many aspects of HR easily assessed clinically. Only fundamental radiological changes to first MTPJ used.
Vanore et al.[52]	Succinct management algorithm.	MPE in stage 1, but MPE is a secondary characteristic? Some criteria described can only be seen intra-operatively. Few clinical features.

MTPJ = Metatarsophalangeal joint, IPJs = Interphalangeal joints, MO = Medial oblique, MPE = Metatarsus primus elevatus, ROM = Range of motion, OA = Osteoarthritis, MC = Metatarsocuneiform.

Figure 3: *Classifications published and analyzed by Beeson and colleagues, putting in evidence positive and negative sides.*

The Coughlin and Shurnas classification

	Range of Motion	Radiographic Findings	Clinical Findings
Grade 0	DF 40°–60° and/or 10%–20% loss compared with normal side	Normal or minimal	No pain, stiffness, loss of passive motion on examination
Grade 1	DF 30°–40° and/or 20%–50% loss compared with normal side	Dorsal spurring, minimal joint narrowing, minimal sclerosis, and metatarsal flattening	Mild or occasional pain and stiffness, pain at extreme DF and/or PF on examination
Grade 2	DF 10°–30° and/or 50%–75% loss compared with normal side	Dorsal, lateral, and possible medial osteophytes; flattened metatarsal head; no more than one-fourth dorsal joint space involvement on lateral view; mild to moderate joint space narrowing and sclerosis; sesamoids typically not involved	Moderate to severe pain and stiffness, pain before maximal DF and/or PF on examination
Grade 3	DF ≤10° and/or 75%–100% loss compared with normal side, loss of PF	As in grade 2, but substantial narrowing, possible cystic changes, more than one-fourth dorsal joint space involvement, sesamoid hypertrophy or cystic changes	Near-constant pain and stiffness, pain throughout range of motion on examination
Grade 4	Grade 3 plus pain at mid-range of motion on examination		

Figure 4: *Coughlin and Shurnas' classification.*

Treatment's algorithm

In a published review by McNeil and colleagues, the relationship between surgical treatments and evidence-based medicine is put in evidence. For each paper evaluated, the authors attribute a level of evidence (I-V) according to the standards proposed by the Journal of Bone and Joint Surgery journal. In conformity to these parameters the recommendation level of the technique in object is consequently associated (Figure 5 and 6).

Level	Therapeutic studies investigating results of treatment
I	High-quality randomized trials with statistically significant difference or no statistical difference but narrow confidence intervals; systematic reviews of level I randomized controlled trials (and study results were homogeneous)
II	Lesser quality randomized controlled trials (eg < 80% follow-up, no blinding, or improper randomization); prospective comparative studies; systematic review of level II studies or level I studies with inconsistent results
III	Case-control series; retrospective comparative studies; systematic reviews of level III studies
IV	Case series
V	Expert opinion

Figure 5: *Levels of Evidence [33].*

Grade	Description
A	Good evidence (level-I studies with consistent findings) for or against recommending intervention.
B	Fair evidence (level-II or III studies with consistent findings) for or against recommending intervention.
C	Conflicting or poor-quality evidence (level-IV or V studies) not allowing a recommendation for or against intervention.
I	There is insufficient or conflicting evidence not allowing a recommendation for or against recommending intervention.

Figure 6: *Recommendation grades [33].*

Mentioning the conclusion of McNeil's work, it is possible to affirm that there is fair evidence (Grade B) in the use of the metatarsophalangeal arthrodesis technique, whereas there is poor evidence (Grande C) in the use of cheilectomy, periarticular osteotomies, metatarsophalangeal joint replacement and biological and non-biological interpositional arthroplasties. Whereas there is a conflicting evidence (Grade I) in the use of cheilectomy associated with Moberg's osteotomy [24].

Notwithstanding the value given to the following affirmations, it is possible to try tracing a utilization profile for the surgical techniques on the base of the joint degeneration grade, localization and type of injury and finally on the base of eventual existing biomechanical causes.

Therefore, the choice of the surgical procedure has to be found itself on the joints' conditions, the aims and the patient's expectations connected to the surgical result and eventually on the patient's personal motivation [23,26-28].

Briefly, the possible treatments can be grouped in:

a. Conservative treatments
b. Surgical treatments:
   i. Joint sparing;
   ii. Joint sacrificing.

Conservative treatment

The conservative treatment should be the first approach. The possible choices referred to this kind of treatment are: oral medications, joint infiltrations, shoe modifications, changes in physical activities and manual therapies. The oral medications are based on the use of non-steroidal anti-inflammatories, but they do not ensure a complete long-lasting benefit. Solan and colleagues, in a work that has been evaluated with a 4th grade of scientific evidence, report the effects of the infiltrative therapy with corticosteroids in the 1st metatarsophalangeal joint. For hallux rigidus grade I they report a benefit of 6 months; a value that can decrease to only 3 months in grade II [29].

Pons and colleagues, in a work declared of level 2 as scientific evidence, compare the corticosteroids infiltrations to the use of hyaluronic acid, concluding that the visual analog scale was significantly improved in patients under infiltrations with hyaluronic acid, with a comparable benefit's duration [30].

The use of insoles and appositely designed shoes limit the irritation of the soft tissues at a dorsal osteophyte level and reduce the movement, the impingement and the mechanical stress of the hallux's metatarsophalangeal joint. A shoe presenting an enlarged or squared tip will reduce the conflict between shoe and skin at the 1st ray. A low heel shoe and insole with a rigid medial part will limit the

dorsiflexion of the 1st finger when walking. A tailor-made orthotic with a support at the navicular bone level and a Morton-type extension will limit hallux movements. The use of orthotics and orthopedic shoes are able to provide a relief from pain during the daily activities and constitute a grade C recommendation during clinical practice [31-33]. While the infiltration treatment represents a medical alternative of a B grade [24].

In recent years, proliferative therapies, such as PRP infiltrations (platelet rich plasma), have been introduced. These therapies in the face of discreet clinical results are not supported by sufficient scientific evidence to be recommended or to give a definitive conclusion on the treatment for hallux rigidus [6]. In the future the use of mesenchymal or staminal cells for joint infiltration to induce chondrocytes proliferation could be available, but such alternatives are still under review.

Periarticular joint sparing surgical procedures

Joint sparing should be the primary purpose during the initial phases of hallux rigidus, in particular in grade I, grade II and in the early phases of grade III according to Coughlin-Shurnas classification. The main focus should be the restoration of the articular mechanics and the elimination of the excessive bone forming on the dorsal aspect of the 1st metatarsophalangeal joint. The success of these techniques depends on the original condition of the articular cartilage [10].

Cheilectomy

The procedure aims to remove about 30% of the dorsal part of the metatarsophalangeal joint. Its purpose is to improve the MTP's mobility by removing the dorsal osteophytes that create conflict with the soft tissues (Figure 7).

Figure 7: *Cheilectomy of the first metatarsus' head [10].*

Cheilectomy is highly recommended at grade II and I, in particular when there's an important dorsal osteophytosis and with a negative grind test.

The recommendation grade reported in the medical literature is C, but, notwithstanding all this, the studies evaluated by McNeil and colleagues report good clinical results.

Moberg's osteotomy in combination with cheilectomy

Moberg's osteotomy consists in removing a bone wedge with a dorsal base at the proximal part of the phalanx close to the hallux joint. Such procedure is indicated if there is a limitation of the hallux dorsiflexion with a preserved plantar flexion [34]. The result of this procedure is the facilitation of the first metatarsophalangeal joint dorsiflexion during the 3rd rocket phase. The osteotomy from a plantar point of view shifts the loading on the head of the 1st metatarsus [35]. The use of Moberg's osteotomy is generally associated to the cheilectomy proper to the initial phases of hallux rigidus (Figure 8).

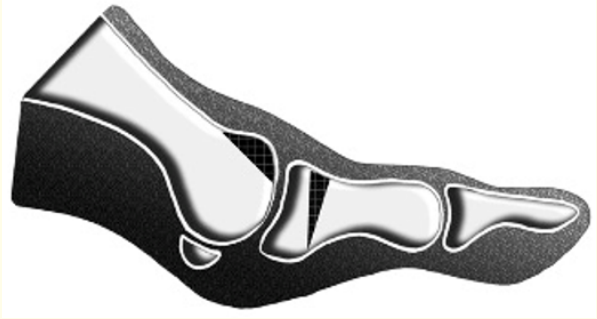

Figure 8: *Moberg's procedures in combination with a cheilectomy in the first meatarsus' head [10].*

In this case, the grade of recommendation reported in the medical literature is I; therefore there is not any sufficient evidence for giving a higher recommendation grade [24]? Other authors, on the other hand, report good results with this procedure and suggest the performance of such osteotomy together with the cheilectomy, with the purpose to obtain the best results with the correct indications, more precisely the initial phases of hallux rigidus with limitation to the articular excursion in dorsiflexion combined with a good plantar flexion associated to a dorsal osteophytosis with negative grind test.

Distal osteotomies of the 1st metatarsus

In the medical literature, many techniques for the 1st metatarsus' osteotomy are reported; the most commonly used are Youngswick's osteotomy and the distal oblique osteotomy. Youngswick's osteotomy, a modification to Austin's osteotomy, is performed with two chevron type osteotomic arms converging in a 60° angle and removing a dorsal bone section which is slightly proximal and parallel to the dorsal arm of the osteotomy itself [36] (Figure 9).

Figure 9: *Youngswick's osteotomy of the 1st metatarsus [10].*

Myerson and colleagues define Youngswick's osteotomy's function as suitable for shortening the metatarsus and plantarise the metatarsal head, allowing the decompression of the articulation and reducing the elevation of the 1st metatarsus. The authors bring the analysis to an end by indicating the use of this osteotomy in the case of functional bio-mechanical hallux rigidus with a long and elevated 1st metatarsus, which requests a head's plantarization when it is particularly associated with hallux valgus [1].

Lundeen described as first the oblique distal osteotomy [37]. It consists in an oblique osteotomy starting from the dorsal - distal aspect of the first metatarsal bone and continuing plantar-proximally with a 30° degrees angle on the sagittal plane (Figure 10).

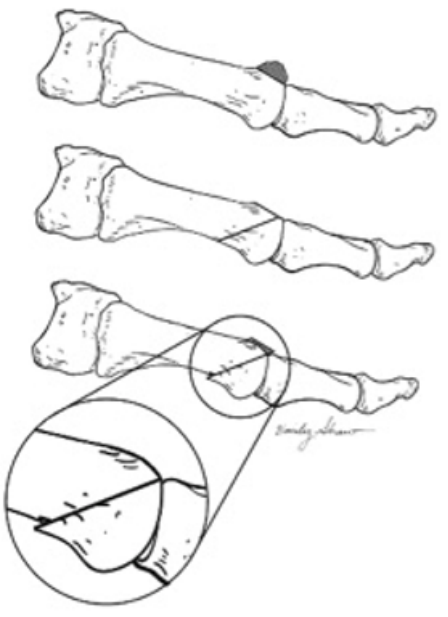

Figure 10: *A representation of the 1st metatarsal's distal oblique osteotomy [10].*

Malerba [38] during a revision of 20 cases with a medium follow up of 11 years, conclude that this is a safe and trustable procedure.

Myerson and colleagues indicate that such an osteotomy is indicated in those cases where the protagonist of hallux rigidus is only a long 1st metatarsus, whereas for all the other cases they prefer the use of Youngswick's osteotomy [1]. Although the several positive responses, it has been retrieved from the medical literature that this procedure has a C as recommendation grade [24].

Arthrodesis of the 1st cuneus-metatarsal (Lapidus procedure)

Described for the first time in 1911 by Albrecht and then published by Lapidus in 1934, it consists in the arthrodesis of the 1st cuneo-metatarsal joint. It is recommended in cases of hallux rigidus associated to a heavily evident cuneo-metatarsal joints' instability with combined elevation of the 1st metatarsus [39]. The corrective power of such arthrodesis is high, for it allows to shorten the 1st ray, besides correcting in a three-dimensional way the position of the 1st metatarsus in the space [1,10]. The performing of this procedure can be associated to distal adjunctive procedures, like a cheilectomy and it is always indicated in grades II and I according to the Coughlin-Shurnas classification.

Figure 11: *A representation of an arthrodesis of the 1st cuneus-metatarsal [10].*

Arthrodiastasis

It consists in an extra-articular distraction of the metatarsophalangeal joint (Figure 12). The basic principle of this procedure is to stimulate bone reparation and to provoke the fibrocartilage production through an off - loading of the articular surfaces [10,40]. It is indicated in the initial stages of arthritis. The downside of this procedure is that the external fixator has to be worn for three months. Notwithstanding the good results reported in the medical literature, the quantity is scarce and the studies are of a grade III, therefore C is the recommendation grade.

Figure 12: *Representation of arthrodistasis through an external fixator [10].*

Surgical procedures with articular sacrifice

Within this group are collected: resection arthroplasty procedures, inter-positional arthroplasty procedures, the use of joint replacement and at last the arthrodesis of the 1st metatarsophalangeal joint. Such procedures are indicated in advanced stages of hallux rigidus like grade III and IV according to Coughlin-Shurnas' classification. The advantage of the arthroplasty procedures in respect to the arthrodesis is the maintenance of the articular movement.

Resection arthroplasty procedures

The technique was initially proposed by Keller (Figure 13). It is based on the resection of the F1's base of the hallux sometimes associated to a soft tissue interposition graft. It is indicated for medium/advanced stages [41]. The main complication is the deformity in hyperextension of the 1st finger with the risk of developing a transfer metatarsalgia. In literature there is insufficient scientific evidence regarding this procedure, and it has C as recommendation grade [24]. It can be used in patients who are advanced in their age (beyond 70 years of age) with low functional requests [28], while on the base of the above described complications and of the difficulty to perform any salvage procedure, it is to be procrastinated in the other cases [42].

Figure 13: *Keller resection arthroplasty [10].*

Articular inter-positional arthroplasty

They represent a captivating opportunity and of an always-growing interest for treating the advanced stages of the metatarsophalangeal arthritis, while always preserving the joint movement. In addition, at the root of such techniques there is the possibility to preserve the articular head by facilitating a future arthrodesis procedure in case of failure [43,44].

The main indication is due to the condition for which the articular degeneration is going beyond the indication of a simple cheilectomy, so from a clinical point of view with a positive grind test. Such procedure begins with the removal of the osteophytes in order to permit an improvement of the articular range of motion; then it is possible to choose a biological interposition graft (for example: joint capsule or extensor hallucis brevis) [3,10] or the possibility to use as joint spacer a hydrogel implant in polyvinyl alcohol implanted into the 1st metatarsus head (Figure 14) [4,45]. In both cases it is possible to provide a C as recommendation grade on the base of the published studies.

These procedures can therefore be discussed with the patient who requests a maintenance of joint motion, but always keeping in mind the possibility of a future arthrodesis surgery in case of an arthritis worsening.

Figure 14: *Intra-operatory representation of an hydrogel implant in polyvinyl alcohol.*

Hallux joint replacement

The opportunity to perform articular prosthesis is not new and has evolved over the time thanks to the improvement of the implants and of the hallux's biomechanical knowledge [46]. Unfortunately, the reported results are conflicting. In fact, a literature revision by Raikin and colleagues demonstrate that the successes and the benefits of the prosthesis alternate themselves to high percentage of failures and revision surgery [47]. Moreover, when a failure occurs, the performance of an arthrodesis procedure often becomes even more difficult.

Even for this case the published works receive a C as recommendation grade, even though the literature seems very cautious, especially in virtue of the reported complications and from the difficulties in a revision phase. We can conclude by affirming that the articular prosthesis finds a wise utilization in advanced arthritis' stages (grade III and IV according to Coughlin-Shurnas' classification) in old patients and /or with low functional requests.

Arthrodesis of the metatarsophalangeal joint

Many works are reported in the literature documenting the validity of the arthrodesis of the metatarsophalangeal joint. Today it is considered the gold standard in the treatment for hallux rigidus, especially in its advanced stages (grade III and IV according to Coughlin-Shurnas' classification) in virtue of its safety and efficacy [22,48,49]. Such technique is also indicated for managing the eventual complications deriving from other surgical treatments; if there is a bone site defects until 5 mm a direct fusion is possible, if the defect is between 5 and 10 mm, then the fusion requests a bone re-balancing of the lateral metatarsal bones; beyond the 10 mm a bone graft is needed to reduce the gap in length of the first metatarsal bone [50]. The main complication reported among the fusion techniques is a pseudoarthrosis, so that it appears on a 20% of the cases [51] but among these until a 67,3% are asymptomatic [52]. Before utilizing this technique, it also has to take into consideration the deriving articular rigidity and so the limitations to the use of the shoes, particularly high heels and the same rigidity which some people retain to be fastidious. The grade of recommendation reported by McNeil and colleagues is B for it is supported by II and III level studies with consistent results [24].

Conclusion

The surgical choices reported in the medical literature are multiple and in a continuous evolution, so that they can create a certain confusion. The arthrodesis of the metatarsophalangeal joint, until today, represents a gold standard in the treatment of advanced hallux rigidus but several other possibilities are gaining even more consistency so that they can be considered a valid alternative.

The clinical-radiographic classification by Coughlin and Shurnas and a careful clinical evaluation, allow us to identify the possible surgical choices. Such choices have to be then discussed with the purpose to center the patient's desires and needs, together with the surgeons' technical abilities.

The conservative treatment should always be the first approach. The cheilectomy represents a good option for the treatment of the initial stages (I, II) associated to Moberg's osteotomy in case of normal plantar flexion of the 1st metatarsophalangeal joint, but with relevant rigidity in dorsiflexion.

Youngswick's osteotomy finds an indication when in grades II and III there is a long and elevated 1st metatarsus and a hallux valgus, especially if the purpose is the shortening of the first metatarsus, the plantarisation of the first metatarsal head and the correction of the valgus. The oblique distal osteotomy (Weil-Malerba) is indicated for grades II and III in particular if the metatarsophalangeal angle is correct and the purpose is the shortening of the first metatarsus and the plantarization of the first metatarsal head.

In case of a positive Barouk's test, so in the presence of bio-mechanical hallux rigidus, Maceira and Monteagudo suggest the performance of a gastroc recession. In the medical literature, the responses to this procedure are still limited, but the biomechanical evidence and the reported results are promising.

The Lapidus arthrodesis is indicated for grades II and III of hallux rigidus when it is associated with a hyper-mobility of the first cuneus-metatarsal joint or when it is necessary to achieve correction of high grades of deformity. It can be associated to distal adjunctive procedures such as a cheilectomy.

The arthrodiastasis represents a surgical possibility finalized to the articular preservation in the initial grades of arthritis, but due to a scarce representation in the medical literature and to the length of the treatment, it should be considered as an alternative in limited cases. In more advanced grades (III-IV) the surgical choices are very competitive. The gold standard, as cited above, is the metatarsophalangeal arthrodesis. The alternatives having a larger accreditation are nowadays represented by the articular inter-positional arthroplasty surgeries, both biological and synthetic (hydrogel in PVA), which allow the maintenance of a good movement without compromising a future arthrodesis. The joint replacement techniques and Keller's procedure are to be addressed to patients with low functional requests and beyond the 70 years of age.

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