

METATARSOPHALYNGEAL RESURFACING FOR THE TREATMENT OF MODERATE AND SEVERE HALLUX RIGIDUS

About 21 Cases and 6 Years Follow-Up

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ABSTRACT • Treatment of advanced stage of hallux rigidus is still controversial in the literature especially nowadays, where active people are less willing to have their joint fused for life.

We present here our results of metatarsophalangeal (MTP) joint resurfacing, using the HemiCap® implant, in 21 cases with a mean follow-up of 6 years as a new alternative of treatment of grade 3 and 4 hallux rigidus. Results at follow-up are promising with good clinical and radiological outcome.

Keywords : hallux rigidus; arthroplasty; resurfacing; Hemi-Cap®

INTRODUCTION

Hallux rigidus is a common degenerative foot disease characterized by pain and a decreased range of motion (ROM) of the first metatarsophalangeal (MTP) joint. The main etiologic reason is unclear, but it may be idiopathic or traumatic, due to some micro- or macrotraumatic lesions of the cartilage. It is associated with a narrowing of the joint space in early stage and characterized by the appearance of dorsal osteophytes in more severe stages, associated to continuous pain and loss of dorsal flexion of the MTP joint [1,2].

A multitude of surgical procedures has been proposed in the literature to overcome the pain and stiffness related to this disease, including cheilectomy [3,4] extension osteotomies [5,6], resection arthroplasty [7,8], interpositional arthroplasty [9,10], hemiarthroplasty [11, 12], total joint arthroplasty [13,14] and arthrodesis [15,16].

The aim of our study is to present the result of 21 cases treated by the new concept of metatarsal head resurfacing of the first MTP joint with a follow-up of six years for the treatment of grade 3 and grade 4 hallux rigidus by using the HemiCap® implant from Arthro-surface.

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Akiki A, Khalil K, Monsellato L. Traitement de l'hallux rigide modéré à sévère par resurfaçage de l'articulation métatarsophalangienne. Une série de 21 cas avec un recul moyen de six ans. *J Med Liban* 2018; 66 (4) : 205-212.

RÉSUMÉ • Le traitement des stades avancés de l'hallux rigidus demeure controversé dans la littérature. De nos jours, les patients actifs sont moins partisans d'une fusion à vie de leur articulation métatarsophalangienne (MTP).

Nous présentons notre série de resurfaçage de la MTP par le l'implant HemiCap®, chez 21 cas avec un recul moyen de 6 ans, comme nouvelle alternative de traitement pour les grades 3 et 4 hallux rigidus. Les résultats du suivi opératoire sont prometteurs avec de bons scores cliniques et radiologiques.

Mots-Clés : hallux rigidus; arthroplasties; resurfaçage; HemiCap®

Patients and Methods

Between September 2009 and September 2017, we conducted a prospective study on 20 patients, 21 feet, operated with the HemiCap® resurfacing implant from Arthro-surface. All patients provided oral or written consent for their X-rays to be used in this publication.

There were 16 women and 4 men with an average age of 63 years (53-68 years old); 66% of patients were graded with stage 3 hallux rigidus according to Coughlin and Shurnas 3 classification and 34% with stage 4 hallux rigidus. All patients had a minimum of 6 months of conservative treatment (Insoles, physical therapy and pain killers) before the operation. All patients were operated by the same surgeon. We measured the articular range of motion (ROM) of the MTP joint before the operation and at the follow-up. All patients had weight bearing AP and lateral X-rays of the foot before the operation and at the review. The visual analogue scale (VAS) was also assessed before the surgery and at the follow-up. The hallux MTP-IP AOFAS score was measured before the operation and at the follow-up for the 20 patients.

The follow-up mean was of 6 years (7 months-9 years). At follow-up, we analyzed the X-rays looking for loosening and/or malpositioning. For 15 patients with a follow-up of more than 5 years (10 patients with grade 3, and 5 patients with grade 4) we conducted a SPECT-CT looking for signs of loosening around the screw. We also analyzed the areas of increased stress activity around the implant but also around the MTP joint.

RESULTS

Nineteen patients over 20 were completely satisfied with their operation. The mean preoperative VAS score for pain improved from 8 to 1 at the final follow-up. The average gain in the 1st MTP ROM at follow-up was of +54° in dorsiflexion and of +25° in plantar flexion. At the follow-up the mean hallux MTP-IP AOFAS score was of 88 (range 74 to 92), instead of 32 (range 24 to 48) before the operation.



FIGURE 1
AP X-rays showing good alignment and good space of the MTPJ at follow-up (6 years)



FIGURE 2. Lateral X-rays showing good alignment and good space of the MTPJ at follow-up (6 years)

On the weight bearing AP and lateral X-rays, we have found no radiolucency around any of our 21 implants at the follow-up. We had one case of malpositioning with the implant in hyperextension. The patient was pain free with a good range of motion in dorsiflexion but lesser in plantar flexion. He was not satisfied with the fact that when standing, his distal phalanx was not touching the ground. By comparing the preoperative and the follow-up X-rays, we did not notice any increase in the wear of the base of the proximal phalanx of the hallux, or any new dorsal osteophytes formation (Fig. 1,2,3). No signs of shortening of the first ray were noted.

For the 15 patients who had a SPECT CT, we did not find any sign of loosening or stress shielding around the screw in the distal 1st metatarsal. We found in 5 patients with grade 4 hallux rigidus signs of increased pressure over the sesamoids without signs of loosening around the implant itself and signs of increasing activity at the base of the first phalanx.

None of the patients in our study had any postoperative infection or a neurovascular compromise.

DISCUSSION

Hallux rigidus is the most common form of degenerative joint disease of the foot and ankle, affecting up to 10% of adults [17,18] with a predominance in the female gender [3,19]. It is classified into four grades, with a relevant clinical and radiological association (Table I).

The early management of hallux rigidus (grade 1 and 2) is based on conservative measures such as icing, NSAIDs, physical therapy and some intra-articular joint injection (Steroid, PRP) [20]. The use of a stiff soled shoe with extra width to accommodate the enlarged joint can be used to limit the motion of the big toe [21]. Adding a rocker bottom to the sole of the shoe may alleviate the pain by decreasing the movement of the arthritic MTP joint [22].

When these conservative approaches fail, different surgical options exist for the treatment of early stage of hallux rigidus [3,23].

If cheilectomy and osteophyte excision is presented as a gold standard surgery in the cases where the joint space and cartilage is preserved, but dorsiflexion is limited by the osteophytes [3,4]; Hastrup and Johnson found that it is a simple procedure with a low complication rate where satisfactory results can be reached [4], Nawoczenski *et al.* found that the patient's gait continues to be altered in spite of the cheilectomy with further degeneration of the MTP joint [24].

The treatment of advanced stages (grade 3 and 4) is more challenging because of the loss of joint space, the restriction of ROM and the contracted state of the peri-articular soft tissue [25]. In advanced state of hallux rigidus, the metatarsal head is denuded of its articular cartilage, however, the sesamoid articulations are usually spared except in most severe cases [23]. This provides challenges for motion preserving treatment options, and the alternative proposed as a gold standard by many authors remains MTP arthrodesis [6,9,26,27].

Many patients are eager today to maintain an active lifestyle for personal and professional reasons and, when confronted with treatment options with advanced stage of hallux rigidus, they tend to reject the surgical option

of MTP arthrodesis [28]. Advances in small joint arthroplasty have revolutionized the care of patients with trauma, stiffness and arthritis of the MTP joint. With the availability of these modern implants, we believe that MTP joint arthrodesis should be limited to end stage salvage procedure [29,30] after ensuring the patient's expectations and comprehension of their MTP joint "permanent pain free stiffness". The ideal implant should be stable enough to decrease pain and to preserve or increase the joint's ROM [31] and at the same time counteracts the forces of propulsion when walking. The experience with the ceramic implants gave good functional outcomes [32]. However, the long-term results showed a high prevalence of loosening and revision surgery [33], synovitis, granulomatous reactions, and metatarsalgia [34]. Other options such as silicone, chrome-cobalt, and titanium have been used [24,33,35] with controversial results.

Most results in the literature about advanced hallux rigidus treatment relate about the replacement or arthrodesis of the 1st MTP joint. Comparative studies in the literature advocate more the use of 1st MTP joint arthrodesis based on patient satisfaction rate [15], yet they highlight the related risks of non-union, three planes malalignment, and wear degeneration of the 1st IP joint [36,37,38].

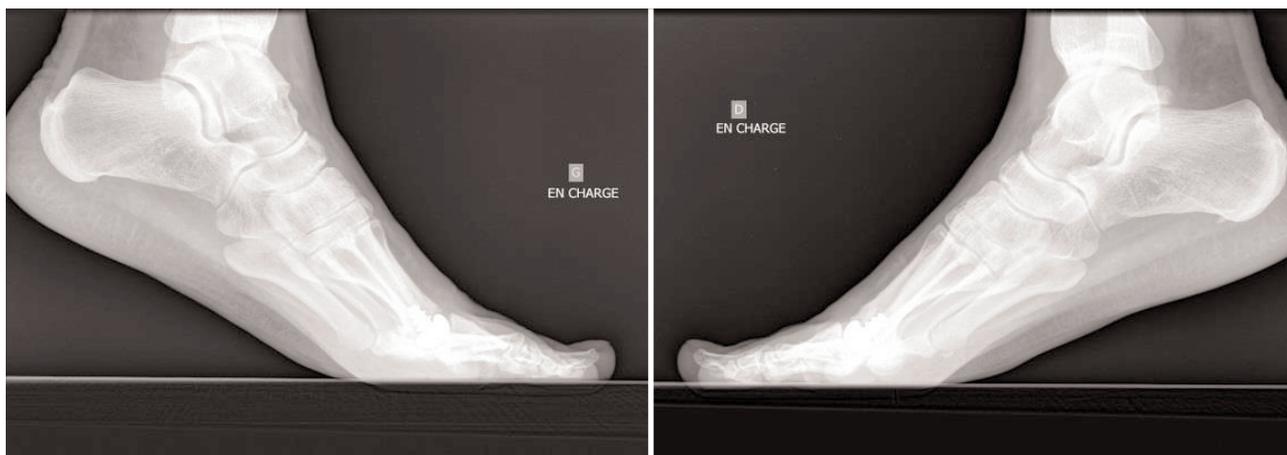


FIGURE 3. Lateral X-rays in dorsiflexion showing good alignment, good space and good ROM of the MTPJ at follow-up (6 years)

TABLE I CLASSIFICATION OF HALLUX RIGIDUS ACCORDING TO COUGHLIN AND SHURNAS [3]

Coughlin and Shurnas Classification

| | <i>Exam Findings</i> | <i>Radiographic Findings</i> |
|----------------|---|---|
| Grade 0 | Stiffness | Normal |
| Grade 1 | Mild pain at extremes of motion | Mild dorsal osteophyte, normal joint space |
| Grade 2 | Moderate pain with range of motion increasingly more constant | Moderate dorsal osteophyte, < 50% joint space narrowing |
| Grade 3 | Significant stiffness, pain at extreme ROM, no pain at mid-range | Severe dorsal osteophyte, > 50% joint space narrowing |
| Grade 4 | Significant stiffness, pain at extreme ROM, pain at mid-range of motion | Severe dorsal osteophyte, > 50% joint space narrowing |

If 1st MTP arthrodesis leads to effective pain relief and restoration of patient's function, it might not be well tolerated by most active demanding patients [39,40].

Phalangeal hemiarthroplasty has also been used for the treatment of hallux rigidus (HR); however, implant loosening and plantar cutout (i.e., plantar dislocation of the implant due to asymmetric forces to both the first MTPJ and the foot) were common problems with this implant.

In their series, Raikin *et al.* demonstrated that 1st MTP hemiarthroplasty and 1st MTP arthrodesis yielded same clinical results, but the advantage of the 1st MTP arthrodesis was the controlled prediction of the postoperative period if no complication occurs. Most of their failures occurred within the first two years after implantation [9].

The meta-analysis presented by Cook *et al.* on 1st MTP joint arthroplasty showed a patients' satisfaction rate varying from 85.7% to 94.5% [41]. Others authors, however, reported the appearance of implant radiolucency's [6,42,43,44], implant subsidence or event implant failure at follow-up [43,44].

The prospective study of Sorbie and Sanders showed an improvement of the AOFAS score of 31 points in 23 patients undergoing a cemented phalangeal hemiarthroplasty at a follow-up ranging from 34 to 72 months [19].

The HemiCap[®] resurfacing addresses primarily the metatarsal side of the first MTPJ and was designed for patients who live actively, because the implant preserves much of the native joint and maintains the joint biomechanics. Its mode of fixation into the bone through a titanium screw gives it more stability and participates in the shear forces transmission across the 1st MTP joint.

Moreover, the implant's dorsal flange is oriented to cover the dorsal aspect of the metatarsal head and to prevent subsequent osteophyte formation after implantation.

Carpenter *et al.* found in their series of 32 implants of metatarsal resurfacing using the HemiCap[®] implant with a 27.3 months of follow-up, an improvement of 58.5 points of the AOFAS score (30.84 preop to 89.31 post-op) with 100% of patients' satisfaction rates and all of the patients willing to undergo the operation again. They had no implant failure, musculoskeletal deformities or neurological complications at follow-up with none of the 30 patients requiring any implant revision or removal [10].

On their series of 27 toes, Aslan *et al.* reported a mean AOFAS score improvement from 40.94 to 85.1 and a mean first MTPJ ROM improvement from 14.36° to 54.38°, with no failures [45].

The results of Erdil *et al.* after 14 metatarsal head resurfacing hemiarthroplasties were very encouraging and reported that the mean first MTPJ ROM had improved significantly from a preoperative value of 22.2° to a postoperative value of 56.3° [46].

Our findings are consistent with those cited in previously published studies (Table II).

Although the results of the resurfacing procedure with the HemiCap[®] have generally been satisfactory, we still have some complications. Hasselman and Shields reported two failures in 25 patients who were treated for high-grade HR using the HemiCap[®] with a mean follow-up period of 20 months. Although one of the failures had resulted from infection, the other had resulted from metatarsal fracture [24].

Hopson *et al.* also reported a case of implant failure;

TABLE II SUMMARY OF LITERATURE REVIEW'S ON HEMICAP[®] RESULTS

| Study | Age y | Cases N | FU (mo) | Complications (N) | Mean ROM | VAS before | VAS after | AOFAS score before | AOFAS score after |
|------------------------------------|-------|---------|---------|-----------------------------|--------------------------|------------|-----------|--------------------|-------------------|
| Hasselmann <i>et al.</i> 2008 [23] | 51 | 25 | 20 | 1 infection 1 metallosis | + 43 (23-65) | NA | NA | 82.1 | 96.1 |
| Carpenter <i>et al.</i> 2010 [10] | 62.8 | 30 | 27.3 | 0 | + 58.47 (89.31-30.84) | NA | NA | 30.84 | 89.31 |
| Aslan <i>et al.</i> 2012 [45] | 58 | 27 | 37.6 | 0 | + 40,02 (54.38-14.36) | 8.3 | 2.5 | 40.94 | 85.1 |
| Erdil <i>et al.</i> 2012 [46] | 63.5 | 14 | 19.5 | 0 | + 34.1 (56.3-22.2) | NA | NA | | |
| Kline <i>et al.</i> 2013 [53] | 51 | 30 | 60 | 4 revisions | + 38.3 (66.3-28) | NA | NA | 51.5 | 94.1 |
| Meric <i>et al.</i> 2015 [49] | 58.7 | 14 | 24.2 | 1 implant removal | + 46.8 (69.6-22.8) | 8.4 | 1.21 | 33.5 | 83.7 |
| Present study | 63 | 21 | 72 | 1 malposition | + 54 DF + 25 PF | 8 | 1 | 32 | 88 |

FU: follow-up ROM: range of motion. ...VAS: visual analog scale AOFAS (American Orthopaedic Foot & Ankle Society): Hallux MTP- IP AOFAS score

this case of failure was due to continuing pain and stiffness 7 months after the operation, with no clinical or radiological evidence of loosening or infection. After removal of the implant, they used an osteochondral plug from the ipsilateral femoral condyle to press fit into the defect in the first metatarsal head [47].

Stone *et al.* reported a case of late hematogenous infection of the first MTPJ 18 months after HemiCap® implantation [48]. This is not considered a direct infection related to the implant or the procedure itself, since the bacteriologic cultures grew *Streptococcus pneumoniae*. Merçi *et al.* reported one revision and fusion of the 1st MTP joint due to persistent pain and joint stiffness at the final follow-up [49].

The first MTP joint is a ball-and-socket joint capable of triplanar motion. In the sagittal plane, the first metatarsal must be capable of plantar flexing and sliding proximally relative to the proximal phalanx. This proximal shift allows the transverse axis to translate dorsally and proximally, which in turn let the proximal phalanx articulate with the dorsal head of the metatarsal. Anything limiting the first metatarsal from plantar flexing or shifting proximally would limit the shift of the transverse axis and ultimately decrease dorsiflexion at that joint [50].

Durrant and Siepert believe that to effectively restrict dorsiflexion at the first MPJ, the plantar structures must cross the transverse axis of motion, lie below the transfer axis of motion, attach to the distal hinge or proximal phalanx, exert a force that is parallel to the longitudinal axis of the first metatarsal, and be present on both sides of the longitudinal axis of the first ray [50]. Because of the encasement of the sesamoids in the flexor hallucis brevis (FHB) tendons, it is necessary to understand how each can restrict first MTP joint range of motion. The origin of the FHB is on the lateral cuneiform and cuboid and crosses the transverse axis to insert on the proximal phalanx. It is a stance phase muscle that acts from mid-stance through the end of propulsion by stabilizing the proximal phalanx against the metatarsal head and ground. Its anatomic position can limit dorsiflexion if the muscle causes excessive tension against the inferior surface of the metatarsal. This tension happens when the muscle is short compared with the length of the first metatarsal or in the presence of sesamoids. If there is excessive plantar tension, then there is increased stress placed on the dorsal head of the metatarsal by the base of the proximal phalanx which, in time, causes bone reactive changes and dorsal spurring.

Mann commented that intrinsic muscles of the foot have to work harder in a pronated foot type during mid-stance and propulsion, which increases plantar tension [21]. This may explain why hallux rigidus is often noted in a more pronated foot type.

The sesamoids have an intricate connection with the FHB tendons because they enhance the pulley action of the muscle and the muscle's function. Sesamoid position relative to the first MPJ has not been fully evaluated [50]. According to Root and colleagues biomechanically the sesamoids assume a more distal position as the first ray plantar flexes and moves posteriorly. The pulley system becomes activated at heel-off, and the first metatarsal head glides proximally on the sesamoid apparatus [51]. In order for this pulley system to operate properly, the sesamoids must be located exactly at the joint where the FHB tendons turn to attach to the proximal phalanx [50,51]. Problems arise when the sesamoid apparatus is proximally located. The limitation of this motion causes increased forces at the dorsal portion of the joint and excessive jamming of the proximal phalanx on the metatarsal head [50]. Camasta relates the connection between the FHB tendons and the sesamoid apparatus and feels that a proximal sesamoid apparatus can be the result of a retraction or spasm of the FHB; a secondary response to painful arthroses [52]. Initial inferior jamming on the sesamoid apparatus can result in erosive changes along the sesamoid grooves that can be visualized at the time of surgery [52].

In advanced stages of HR, the sesamoid articulations have usually been spared, except in the most extreme cases. However, sesamoid arthrosis can cause MTPJ pain; thus, it is important to ensure accurate localization of the source of the pain.

The toe sesamoids must be evaluated by direct palpation during dorsiflexion of the hallux. Any pain localized to the plantar aspect of the MTPJ, when palpating during dorsiflexion, can result from sesamoid arthritis. If the sesamoids are involved, the pain will continue even after hemiarthroplasty. This is not necessarily a contraindication to hemiarthroplasty; however, during surgery, the articular surface of the sesamoids must be debrided and sesamoidal contouring planned to avoid impingement. Alternatively, arthrodesis can be used.

The possible reasons for limited dorsiflexion of the first MTPJ after hemiarthroplasty include insufficient adhesion release, improper size of the implant selection and inadequate postoperative rehabilitation. To prevent these problems, adequate first MTPJ soft tissue release and precise operative planning are very important. We believe that if dorsiflexion remains < 90°, the flexor hallucis brevis should be released subperiosteally from the tendon insertions and any MTPJ adhesions should be released.

The alignment of the implant during the operation is also very important. We should respect the K wire positioning on the AP and lateral X-rays during the operation, before putting the final implant because any malpo-

sitioning will likely result in asymmetric forces over the implant and can cause pain and erosion in the bone, resulting in implant failure (Fig. 4).



FIGURE 4

AP and lateral X-rays showing mal alignment of the implant and extension of the MTPJ at follow-up (4 years)

The surgical technique has advantages for the patients and the surgeons. These include pain relief, little restriction of joint motion, permitting dorsal roll back (excursion) of the phalanx on the resurfaced metatarsal head, a relatively short learning curve for most surgeons and preservation of a wide range of possible surgical options if further complications occur in time.

CONCLUSION

In comparison to literature, our results confirm the viability and the efficiency of the HemiCap® resurfacing system over time. Our limitations, due to the paucity of this pathology, are the lack of a control group treated with MTP joint arthrodesis.

MTP joint resurfacing using the HemiCap® implant for grade 3 and grade 4 hallux rigidus treatment seems to be a good alternative for patients preferring a mobile MTP joint. This method of treatment assumes all what we are looking for in any prosthetic implant; it restores a pain free, well aligned mobile joint with no signs of loosening, recurrences or wear at a 6-year follow-up.

Longer series with longer follow-up are still needed to validate these results as well as those of the literature, but it opens a door to an alternative modern treatment for hallux rigidus.

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