



Evolution of the first metatarsophalangeal joint replacement

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Abstract

Introduction The diseases of the first metatarsophalangeal (1 MTP) joint that require surgical treatment include osteoarthritis (69 %), rheumatoid arthritis (26 %), tumors, tumor-like diseases and purulent arthritis (5 %). The treatment of arthritic 1 MTP is aimed at reducing pain and improving function. Joint replacement implants are meant to support body weight, maintain the length of the first metatarsal, provide metatarsal-sesamoid joint functioning and restore joint motion.

The purpose of the work was to analyze data from foreign and domestic literature on endoprosthetics of the 1 MTP, and briefly present analytical data on the results of using various implants.

Material and methods The article presents the summary of the Russian and foreign publications on 1 MTP joint replacement. The original literature search was conducted on key resources including PubMed, eLIBRARY, MedLine, Scopus. The search strategy was comprised of keywords: “replacement of the first metatarsophalangeal joint”, “surgical treatment of hallux rigidus”, “osteoarthrosis of the first metatarsophalangeal joint”, “results of endoprosthetics of the 1st metatarsophalangeal joint”, “modernization of implants of the 1st metatarsophalangeal joint”. Publications brought out between 1968 and 2022 inclusive were analyzed.

Results and discussion The ideal implant should restore functional range of motion, improve function, maintain joint stability, distribute the stress across joint surfaces being wear-resistant. Over the years, various materials have been used to provide simple and reliable designs. Implants have been improved and divided into groups based on material and design, limited degrees of freedom, tribological pair composition, and the amount of articular surface replacement.

Conclusion New generation implants have a more durable design, anatomical shape and improved osseointegration. The advances in joint replacement have resulted in greater patient satisfaction and increased service life. The complication rate for replacement of the 1 MTP joint remains high. This indicates the need for continued research and further work to improve implants to make them more effective and easier to use.

Keywords: endoprosthesis replacement of the first metatarsophalangeal joint, osteoarthritis of the first metatarsophalangeal joint, evolution of endoprosthesis replacement of the foot joints

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INTRODUCTION

The presence of longitudinal and transverse arches is one of the main features of the foot to ensure uniform distribution of the load between the heel tubercle and the 5th metatarsal bones and provide a shock-absorbing function during walking and running. An average 50 % of the support falls on the head of the first metatarsal bone, which is part of the first metatarsophalangeal joint (1 MTP). The 1 MTP joint is the important joint for the biomechanics of human walking, providing the body with horizontal acceleration in the stance phase [1, 2]. Even minor damage to this joint can lead to impaired foot functioning, limited employment and everyday activities.

The diseases of 1 MTP joint that require surgical treatment are osteoarthritis (69 %), rheumatoid arthritis (26 %), tumors, tumor-like diseases and purulent arthritis (5 %). The treatment of arthritis of the 1 MTP is associated with the high incidence of diseases of this anatomical structure. Osteoarthritis 1 MTP joint (hallux rigidus) is a degenerative disease associated with damage to articular cartilage. The etiology of the pathology is multifaceted and is associated with various traumatic, biomechanical, metabolic, neuromuscular, postoperative and other factors [3, 4]. The doctor has to choose the treatment strategy depending on the degree of arthritis, the patient's age, his/her expectations and level of activity. Conservative treatment can provide satisfactory results in selected patients with grade 0 and grade 1 arthritis of the first metatarsophalangeal joint with low functional demands. Organ-preserving operations are saved for middle stages of arthritis to include isolated cheilectomy or osteotomies of the proximal phalanx and metatarsal bone. Arthrodesis, total joint replacement and Keller arthroplasty can be offered for Grade 3 arthritis with the articular surfaces being completely destroyed [5].

Although arthrodesis of the first metatarsophalangeal joint remains the “gold standard” for hallux rigidus, the technique may fail to provide a significant functional improvement. Arthrodesis can be associated with such complications as nonunion, malaligned axis of the first ray, and broken metal fixators [6, 7]. Reconstruction joint replacement has become common for joint surgery to allow weight-bearing function using an implant. Modern implants provide restoration of movements in the 1st PFJ and support the function of the metatarsosesamoid joints [8]. Indications for total replacement of 1 MTP joint include idiopathic, post-traumatic and degenerative arthritis, revision surgeries using the Brandes – Keller and Morbus Köhler methods and rheumatoid arthritis. There are many types of endoprotheses for the 1 MTP joint differing in structure, materials, and tribological friction pair. Although each type of implant has gone through a long evolutionary path of several decades, endoprosthetics of 1 MTP joint leads to conflicting results and high rate of postoperative complications [9].

The objective of the work was to analyze foreign and Russian publications on total replacement of the 1 MTP joint and present analytical data on outcomes with various implants.

MATERIAL AND METHODS

The article presents generalized information from Russian and foreign publications on joint replacement of 1 MTP joint, evolution of the development and design of implants for the 1 MTP joint and presents a classification of the most common 1 MTP joint implants. The original literature search was conducted on key resources including PubMed, eLIBRARY, MedLine, Scopus. The search strategy was comprised of keywords: total replacement of the first metatarsophalangeal joint, surgical treatment of hallux rigidus, osteoarthritis of the first metatarsophalangeal joint, results of endoprosthetics of the 1st metatarsophalangeal joint, modernization of implants the 1st metatarsophalangeal joint. The analysis was based on materials published between 1968 and 2022. In addition to that, the review included information from articles reporting functional anatomy and biomechanics of the 1 MTP.

RESULTS AND DISCUSSION

Knowledge of the anatomy and biomechanics of the 1 MTP joint plays an important role for successful total replacement of the joint and prevention of intra- and postoperative complications.

The 1 MTP joint consists of 4 bones and includes the head of the first metatarsal, the base of the proximal phalanx of the first toe, and two elliptical sesamoid bones. The joint is shaped spherical and has 3 degrees of freedom: flexion/extension, abduction/adduction, external/internal rotation. There are two grooves separated by a ridge, forming articular facets for the sesamoid bones, included in the thickness of the joint capsule, which is a platform and forms a sesamoid hammock on the plantar surface of the head of the first metatarsal bone [10]. The 1 MTP joint capsule is attached to the lower part of the head of the first metatarsal proximally and to the base of the proximal phalanx of the first toe distally. On the sides, the capsule is strengthened by collateral ligaments to provide additional stability. On the medial side, the tendon of the adductor hallucis muscle and the medial head of the tendon of the big toe short flexor are fixed to the sesamoid hammock ligament. The sesamoid bones are involved in uniform distribution of the load, protecting the metatarsal and phalangeal articular surfaces, and serve as support at push-off phase. The sesamoid hammock is part of the fibrocartilaginous plantar plate and creates a strong connection between the links of the joint. The 1 MTP joint is strengthened by the tendon of the short extensor pollicis muscle, which is attached to the superior portion of the main phalanx, and the tendon of the long extensor pollicis muscle, which is fixed to the distal phalanx on the dorsal side. Both tendons are secured by a fibrous hood, which is woven into the capsule and provide additional strength to the joint [11, 12].

About 40 % of the stride cycle falls on the forefoot and is gradually redistributed from the lateral to the medial portion, so that the 1 MTP joint has an important function in the biomechanics of the gait. The motion in 1 MTP joint normally ranges from 45° plantar flexion to 90° dorsiflexion during passive movements, and 44° with the load. Based on the assessment of the load on the 1 MTP joint during gait, measured during the final stance phase of the foot, a mean value of the force acting on the joint is proposed to be $0.86 \times \text{body weight}$. For a 70-kg person, this value is 61 N [13, 14].

Recent research showed that the links of anatomical structures in the form of ligaments, muscles, bones and capsule of the 1 MTP are a single whole, and a pathology of a component leads to a cascade of biomechanical disorders and irreversible consequences [15].

Historically, the original goal of creating a 1 MTP joint implant was to develop a design that was as simple and reliable as modern knee or hip implants. However, engineering design was associated with structural and functional difficulties of 1 MTP. Classifications of the most common 1 MTP joint implants are presented in Table 1.

Endoprostheses of the 1 MTP joint are divided into the following groups:

- 1) by limited degrees of freedom: constrained or unconstrained;
- 2) by tribological pair: metal-metal, metal-polyethylene, ceramics-ceramics, pyrocarbon, silicone;
- 3) by articular surfaces to be replaced: unipolar or bipolar [16].

The extent of destruction of the articular surfaces of the metatarsal head and the base of the proximal phalanx are essential for the selection of the implant design. There are no recommendations in the literature for choosing a particular implant; in most cases, it is the surgeon who determines the strategy based on his own experience, familiarity with the endoprosthesis and the equipment used for the operation [17].

Table 1

Classification of Common First Metatarsophalangeal Implants [18, 19]

I. Hemi-Joint implants	
	Swanson silicone implant, 1968; Swanson design/Weil modification, 1977
	Swanson metal implant, 1986; Townley, 1986; HemiCap first generation manufactured by Arthrosurface, 1998; HemiCap second generation manufactured by Arthrosurface, 2012
II. Total MTP replacement	
Constrained	Double-stemmed silicone implant of the 1 MTP joint designed by Swanson, 1974
	Kampner-designed implant - double-stemmed prosthesis with a central hinge. The implant was made from a silicone-polyester composite made by Cutter Biomedical, 1971
	The Lawrence-designed silicone intermedullary, double-stemmed, hinged implant ; the LaPorta-designed silicone intramedullary double-stemmed hinged total implant manufactured by Sutter Corporation Inc., 1982
	Helal silicone elastomer implant reinforced with a Dacron core 1977. Double-stemmed great toe implants with titanium grommets designed by Swanson manufactured by Wright Medical, 1985
Non-constrained with metal-polymer friction pair	Total first arthroplasty system produced by Richards Manufacturing with the two-piece implant having a phalangeal component made of ultrahigh molecular weight polyethylene (UHMWPE) and a metatarsal component of stainless steel, 1975
	Total great toe implant, manufactured by Biomet Inc., is a two-component, press-fitted implant with the metatarsal component made from a titanium alloy, while the phalangeal base component being made of UHMWPE or UHMWPE with a metal base (Warsaw, USA), 1989
	Bio Action great toe implant (OsteoMed, Addison, Texas). The metatarsal component is constructed from cobalt-chrome, while the phalangeal component is constructed from titanium, and polypropylene (Texas, United States), 1991
Non-constrained ceramic on ceramic	Moje Ceramic implant (Germany), 2004
Non-constrained metal on metal	The Integra Movement Great Toe System total arthroplasty (New Jersey, United States), 2019
III. Interposition arthroplasty	
	Interpositional arthroplasty using a Regno stainless steel implant, 1975
	Interpositional arthroplasty using a Barouk stainless steel implant, 1987
	Polyvinyl alcohol (PVA) hydrogel implant, Cartiva (Alpharetta, GA), 2016

Silicone implants

Swanson was the first who developed two types of silicone semi-interpositional implants in 1968. The first metatarsal head implant was used and was later replaced by an implant for the base of the proximal phalanx of the first toe. It was a single-stem design with a silicone head and stem designed to replace the articular surface of the base of the proximal phalanx (Fig. 1a). Swanson suggested that an implant placed on this side of the joint would be more stable being not subjective to excessive stress. The implant was used according to the principle of Keller arthroplasty and acted as a spacer in the interarticular space with slightly increased range of motion [20, 21]. Ris et al. reported a 48-month follow-up of 53 patients who were treated with 68 Swanson silicone hemi-implants. Physical examination of the patients revealed a decreased range of motion in 1 MCP joint compared with preoperative level recorded in 62 % of patients. Implant destruction was noted in 57 % of cases during radiological examination [22].

In 1971, Kampner developed the first double-stemmed silicone implant, which was made of silicone and polyester. The first design contained polyester grommets attached to the stems, suture material for fixation to the periosteum and improved stability of the implant. The polyester grommet was later discontinued due to joint stiffness and increased load on the hinge [23, 24].

In 1974, Swanson introduced a double-stemmed design with two tapered stems and a flexible u-shaped hinge to provide dorsiflexion (Fig. 1b). The hinge of the implant was criticized for absence of physiological range of motion. The stems did not bend in the frontal and lateral planes. Placement of the original design suggested shortening of the stem of the phalangeal implant. A year later Swanson et al. presented a silicone implant with shortened stems [25].

In 1985, Wright Medical manufactured the Swanson design double-stemmed implant with titanium bushings. The grommets were designed to protect the stems at most vulnerable sites between the edge of the resected bone and the hinge. The grommets were pressed in the bone marrow canals before placement of the implant [26]. In 1991, Gerbert reported a retrospective review of the patients undergoing arthroplasty with Swanson implants with titanium grommets. Twenty-two patients were examined over a period of 33 months, with a mean age of 61 years. The survey was performed using the PASCAM scale (Podiatric Audit in Surgery and Clinical Outcome Measure), and satisfactory results were obtained in 72 % cases. The angle of dorsiflexion of 1 finger averaged 21° [27, 28].

In 1982, Sutter Biomedical introduced LaPorta and Lawrence designs of silicone hinged implants of the 1 MCP (Fig. 1c, d). The implants are currently manufactured by Futura Biomedical. Both designs include rectangular-taper stems. The proximal stem was slightly larger and longer than the distal one, tilted 15° dorsally to provide physiological inclination of the first metatarsal preventing stress to the hinge. The LaPorta implants include right, left and neutral models with different angle of inclination of the stems in the horizontal plane. The angle of inclination of the stems of the neutral design is 0° in the horizontal plane in the right and left versions the inclination angle is 10°. The Lawrence implant has a neutral shape. The hinge of both implants is shaped like an hourglass, with flexion occurring at the central part of the joint. The LaPorta design is symmetrical from dorsi to plantar and is designed for 60° of dorsiflexion. Both sides of the heads have a flat surface to ensure complete adherence to the bony edges. The Lawrence design includes the hinge portion of the main phalanx being extended dorsally and slanted downward. Its main advantage is 85° of dorsiflexion. The plantar angle on the phalangeal side of the hinge reduces the amount of resection of the main phalanx and increases the stability of the joint by preserving the insertion of the flexor tendon pedicles [29, 30, 31].

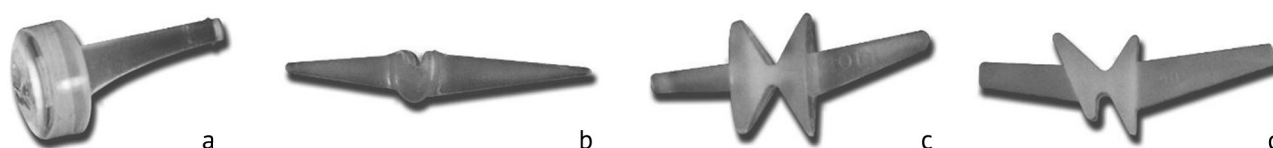


Fig. 1 Appearance of silicone implants of the 1 MTP joint: (a) Swanson design of the single-stemmed implant of the 1 MTP joint, 1965; (b) Swanson design of the double-stemmed hinged implant of the 1 MCP, 1974; (c) LaPorta design of the double-stemmed hinged implant of the 1 MTP manufactured by Sutter Biomedical, 1982; (d) Lawrence design of the double-stemmed hinged implant of the 1 MTP manufactured by Sutter Biomedical, 1982 [26]

Several studies have been conducted to evaluate the effectiveness of flexible articulated implants. In 1989, Granberry et al. reported a retrospective study of 90 patients who underwent 1 MTP joint replacement with silicone flexible hinged implants for three years. Most patients reported satisfactory results in terms of pain intensity. Granberry found three main disadvantages with flexible articulated implants. At follow-up examinations, 30 % of patients had less than 15° of dorsiflexion at 1 MTP joint (dorsiflexion of the first toe is a key component of human gait biomechanics). Skin lesions were observed in 69 % of patients who had painful keratoses on the plantar surface of the foot at the head of the first metatarsal resulting from the short ray. Granberry et al. reported osteophytes at the 1 MCP joint. Radiological examination showed osteophytes formed around the implant in 53 % of patients [32].

Metal implants

Metal hemiendoprotheses were developed to eliminate excessive resection of the articular surface and shorten the first ray with use of silicone implants [33]. In 1986, Swanson developed a titanium hemi-implant that was used to replace the articular surface of the main phalanx (Fig. 2a). In 1987, Townley modified the implant that was manufactured using an alloy of cobalt and chromium (Fig. 2b). It had a thin xiphoid rod that required no additional processing of the bone marrow canal. The implant included a thin head that would limit the resection of the proximal phalanx and maintain soft tissues attached. The implants are manufactured by Wright Medical in five sizes (from 0 to 4). Phalangeal half-implants did not fully reduce pain and improve joint mobility, since the degenerative head of the first metatarsal had not been primarily treated. Subsequently, the grinding procedure of the head of the first metatarsal became mandatory with use of this implant model [34].

In 2009, Konkel et al. reported a retrospective review of 33 patients with arthritis of the 1 MTP who received hemiendoprotheses. The average follow-up period was 6 years. Relapse of dorsal osteophyte growth was detected in patients with early signs of arthritis grade three. Postoperative foot and ankle condition measured with the American Orthopedic Foot and Ankle Society Score (AOFAS) used in the USA [18] was 67.

The HemiCAP first-generation System (Arthrosurface Inc, Franklin, MA, USA) was developed for arthroplasty of metatarsal head in 1998 (Fig. 2c). HemiCap is a two-part tapered metatarsal head metallic implant that incorporates a titanium alloy fixation component connected via taper to the cobalt chromium alloy articular contoured component [35].

In 2012, Arthrosurface developed a second generation HemiCap DF (Dorsal Flange) implant for the first metatarsal head (Fig. 2d). The HemiCAP prosthesis was adapted to include a dorsal flange. This might improve the range of dorsiflexion not seen with the traditional model. The implant's dorsal flange is oriented to cover the dorsal aspect of the metatarsal head and to prevent subsequent osteophyte formation after implantation [36].

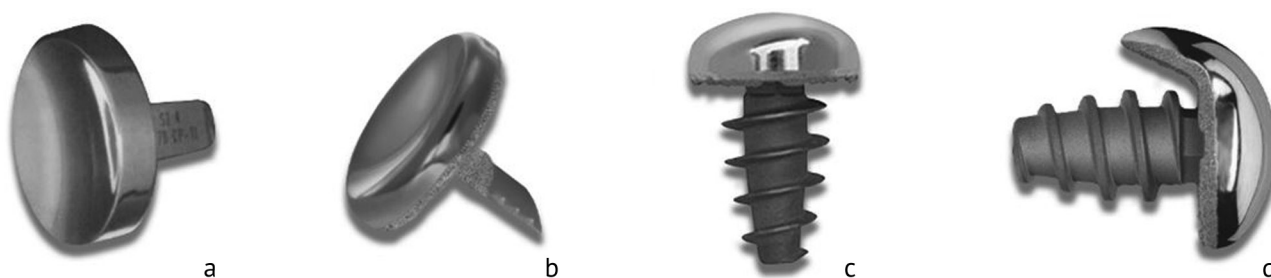


Fig. 2 Appearance of metal hemiendoprotheses of the 1 MTP: (a) hemi-implant fabricated by Swanson to replace the head of the first metatarsal and manufactured by Wright Medical, Tennessee, USA, 1986; (b) hemi-implant designed by Townley to replace the head of the first metatarsal and manufactured by Wright Medical, Tennessee, USA, 1986; (c) HemiCAP first-generation System (Arthrosurface Inc, Franklin, MA, USA) used to replace the head of the first metatarsal; (d) HemiCAP second-generation hemi-implant to replace the head of the first metatarsal, Arthrosurface Inc., Franklin, Massachusetts, USA, 2012 [37]

In 2021, Jørsboe et al. reported a review of 116 patients with hallux rigidus treated with the first- and second-generation HemiCap implants. At 2 years, 4 years and 6 years, the implant survival was 87 %, 83 % and 74 %, respectively. At the mean five-year follow-up, 47 patients had dorsiflexion of 45°. Functional results measured with AOFAS scored 77.2 ± 2.8 and Visual Analogue Scale (VAS) score was 2.0 ± 1.6 [38]. With the growing popularity of two-rod silicone implants, a “revolution” took place in the creation of two-component unconstrained implants. Silicone implants failed due to excessive wear and tight design. With greater understanding of the biomechanical parameters of the 1 MTP joint, there is a need for a design that would address weight-bearing characteristics, sliding, and multidirectional joint motion. The 1 MTP joint is a hinge joint, and with the proximal phalanx being flexed at an angle of greater than 30°, its axis in the horizontal plane shifts

to the dorsal side. Dual-stemmed silicone implants were not adjusted to the normal physiological range of motion, abnormal loads applied to the implant eventually led to its failure [39]. In 1985, Zeichner attempted to construct a ball-shaped implant from existing materials at the time in order to avoid the piston-type kinematics effect characteristic of hinged implants and create a prosthesis with a variable axis [40]. In 1989, Merkle and Sculco developed an implant made of titanium alloy and high-density polyethylene and used polymethyl methacrylate bone cement for its fixation. Their design did not include an intramedullary stem on the metatarsal component. Two implants were removed due to the high loosening rate (54.5 %). The authors concluded that cemented 1 MTP joint replacement did not provide satisfactory results and recommended further research to improve fixation techniques [41].

In 1989, Koenig developed a two-piece system for replacing 1 MTP joint, similar to that used for knee replacements. The metatarsal head component had an intramedullary rod and was made of titanium alloy. It included a plantar surface reproducing the condyles of the metatarsal head for articulation with the load-bearing sesamoid bones. The phalangeal component was made of ultra-high molecular weight polyethylene with an intramedullary rod, and both components were placed using the press-fit method [42]. A similar Total Toe System is produced by Biomet (USA, Warsaw) and characterized by entirely polyethylene or titanium phalangeal components. Plasma spraying of both stems is performed to improve integration into the medullary canal (Fig. 3a) [43].

In 1991, Koenig followed up 18 patients at 18 months after surgery, examined radiographs to measure the intermetatarsal angle, hallux abduction angle, first metatarsal length, and implant alignment. Adequate alignment and complete osseointegration were seen in 7 cases. The full range of motion in the 1 MTP was regained in 12 cases, and a revision was required in one case with metallosis detected. In 1996, Koenig and Horwitz published a study of 61 patients over a 5-year postoperative period. Excellent results were obtained in 80.5 % of patients, and poor outcomes of varying degrees were noted in 10 % of cases [44].

In 1991, Orthopedic Bio-systems developed the Bioaction Great Toe System implant. The implant has a metatarsal component made of cobalt-chrome and a phalangeal component made of titanium and a polyethylene insert. The design is manufactured by Osteomed. Pulavarti et al. reported 77 % of patient satisfaction, while 23 % showed radiographic evidence of implant loosening and subsidence [45]. A new total implant, the Movement Great Toe System, manufactured in the USA (Integra, New Jersey) entered the market in 2019 (Fig. 3b). The anatomically shaped components have a cobalt-chromium articular surface. Titanium plasma spraying was used for the posterior surface of the implant to improve osseointegration. The design of the stem of the implant differs from other models on the market. Cylindrical stem with four ribs provides improved fixation and anti-rotation stability. The metatarsal component has a dorsal flange to prevent re-formation of osteophytes. The proximal phalanx component contains suture holes on the plantar portion of the implant to allow reattachment of the flexor apparatus in case of injury. The endoprosthesis was first implanted in January 2018 and is available in four sizes [46].

In 2016, Johnson reviewed 35 patients with arthrosis of the 1 MTP 2 years after arthroplasty performed using the Movement Great Toe System. He found that 82 % of patients were satisfied with the results evaluated with PASCOM, and 62.9 % were free from pain when using shoes. The average range of motion was 57.6° in dorsiflexion and 10.5° in plantar flexion. There were no radiological signs of loosening of the implant components [47].

Ceramic implants

In 1994, Moje Ceramic Implants (Petersberg, Germany) introduced zirconium ceramic implants for the 1 MTP joint. The metatarsal component is hemispherical in shape and the phalangeal component is concave. The original design included two titanium positioning screws for the metatarsal and phalangeal components and a press fit method was employed with the design (Fig. 3c).

The implant is plasma sprayed with apatite and fosterite crystals to improve osseointegration and has very good biocompatibility and excellent wear resistance [48, 49].

In 2020, Nagy et al. reported 30 patients treated with a ceramic total implant of the first metatarsophalangeal joint. The mean follow-up period was 81 ± 27 months. After surgery, the average range of passive motion of the joint was 32° dorsiflexion, the mean AOFAS scored 84. 24 patients (84 %) were satisfied with the result. The radiographs revealed a change in the angle of inclination of the implant and migration of the proximal or distal components. Complications included one case of wound infection. Revision was performed in 5 cases (16 %) due to loosening, migration, subluxation or destruction of the implant stem. The survival rate of implants was 92 % at 5 years, 85 % at 7 years, and 78 % at 9 years [50].



Fig. 3 Appearance of total implants of the 1 MTP joint: (a) Total Toe System implants manufactured by Biomet, Warsaw, USA, 1989; (b) Movement Great Toe System implants manufactured by Integra, New Jersey, USA, 2019; (c) ceramic implants from Moje Ceramic Implants, Petersburg, Germany, 2004 [51]

Hydrogel implants

A new polyvinyl alcohol hydrogel implant (CARTIVA, Georgia, USA) received FDA approval in July 2016 (Fig. 4) and was tested in the UK and Canada. Both studies showed promising results before entering the US market. The implant was made of polyvinyl alcohol hydrogel and acted as a spacer between the first metatarsal and the base of the proximal phalanx. As non-toxic and non-carcinogenic polymer polyvinyl alcohol is used in contact lenses and food packaging materials. In terms of its ability to resist stress, it has an ultimate tensile strength at a pressure of 17 MPa comparable to human cartilage and a similar water content [52, 53].



Fig. 4 Hydrogel implant of the 1 MTP made of polyvinyl alcohol (CARTIVA, Georgia, USA, 2016) [54]

In 2018, Baumhauer et al. prospectively compared a synthetic hydrogel implant and arthrodesis in terms of safety and effectiveness (arthrodesis of the first metatarsophalangeal joint is used to treat severe degrees of arthrosis). Upon completion of 24 months. study in both groups of patients who underwent both endoprosthetics with a Cartiva hydrogel implant and arthrodesis, a significant decrease in pain intensity was noted on the VAS scale. Subsequent secondary surgeries occurred in 11 % implant patients and was equivalent to the reoperation rate in the first metatarsophalangeal joint arthrodesis group (12 %). The hydrogel implant maintained function and dorsiflexion (mean 29.7°). Radiological comparisons did not reveal loosening or destruction of the implant, although two patients developed a periosteal cyst in the proximal phalanx [55, 56].

Lee et al. explored 90 patients hallux rigidus treated with hydrogel implant. The mean VAS score was 4.0 and AOFAS measured 64 points. On postoperative plain radiographs, implant subsidence was observed 60 % at 4 weeks after surgery and 90 % at the final follow-up. Fifty percent (5/10) showed radiologic lucency around the implant. Bone resorption around the implant was radiologically detected in 50 % of patients [57, 58].

Overall, hydrogel implants have a promising future. Major upgrade of hydrogel implant design is essential for prevention of implant migration.

CONCLUSION

The use of silicone implants provided satisfactory functional outcomes in 72 % of cases evaluated with PASCOM. The study of MTP joint arthroplasties performed with Swanson double-stemmed great toe implants with titanium grommets showed most favorable outcomes among silastic implants. The rate of survival for metallic hemi-great toe implants was 74 % and the HemiCap DF implant scored 77 on the AOFAS scale. The use of total metal implants provided 82 % satisfactory results evaluated with PASCOM after placement of the Movement Great Toe System implant. Patients treated with Moje Ceramic total implants were satisfied in 85 % of cases. The use of hydrogel implants resulted in 50 % poor outcomes. Total first MTP joint replacement arthroplasties have been developed over the last six decades with advances in technology facilitating progressive changes in materials and surgical technique. New generation implants have a more durable design, anatomical shape, improved osseointegration, and are made from the most wear-resistant materials. These advances have resulted in greater patient satisfaction and implant longevity. The rate of revision surgeries after total first MTP joint replacement is decreasing and is comparable to the rate of re-operations after arthrodesis. However, the complication rate remains high after first MTP joint replacement. This indicates the need for continued research and further work to improve implants for effective and easier use.

Conflict of interest None of the authors has any potential conflict of interest.

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Ethical review is not required.

Informed consent from patients is not applicable to this study.

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