



Silastic replacement of the first metatarsophalangeal joint: historical evolution, modern concepts and a systematic review of the literature

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- Silastic implants for the first metatarsophalangeal joint (MTPJ) have been in use for over 50 years. Initial reports were associated with high failure rates leading to development of new designs that are currently in use.
- The aim of this article is to review the historical evolution and the outcomes of silastic implants for the treatment of end-stage OA of the first MTPJ. Databases were searched for studies reporting the outcomes of silastic implants for the first MTPJ. Various relevant search terminologies were used. Studies reporting the outcomes of metallic implants or arthrodesis were excluded.
- The literature search revealed 522 studies, of which 28 were included. Eight studies used single-stemmed implants and 20 used double-stemmed implants for their patients. Twenty-eight studies had a total of 2354 feet with silastic replacements in 1884 patients (1968 to 2003) with an average age of 53 years and the average follow-up was 85.3 months. There were a total of 5.3% (124 feet) failed prostheses. Improvement in pain was reported in 76.6% (1804 feet) with an average patient satisfaction rate of 84%. Radiological changes around the implants were found to be significantly higher with single-stemmed implants (30.3%) compared to the double-stemmed implants (14.7%) ($p < 0.05$).
- Significantly more single-stemmed implants failed (11%) than the double-stemmed implants (3.6%) ($p < 0.05$). Despite the initial reports of failed implants and complications, first- and second-generation silastic implants were associated with high patient satisfaction and pain improvement. Current literature lacks long-term outcomes of implants currently in use.

Keywords: first MTPJ replacement; silastic implants; silicone synovitis

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Introduction

Osteoarthritis (OA) of the first metatarsophalangeal joint (MTPJ) has been reported to affect between 35% and 65% of adults older than 65 years.¹ The pain and stiffness associated with osteoarthritis of the first MTPJ can lead to difficulties in activities of daily living and altered gait pattern.² End-stage arthritis or hallux rigidus has been well documented in the literature for more than a century, but a consensus on its management has not been established and, therefore, the surgical options remain controversial.³ The traditional options for operative management of end-stage arthritis include excision arthroplasty, implant arthroplasty and arthrodesis. Excision arthroplasty has gradually become less popular with a limited value in current practice.³⁻⁵ Arthrodesis, popularized by McKeever in 1952,⁶ remains the gold standard and is the preferred choice due to its generally more predictable results, patient-reported outcomes and surgeons' familiarity with the procedure.⁷ The options for replacement include a silastic (silicone) or a metallic implant. It follows the basic principles of any joint-replacement surgery aiming to reduce pain, restore joint kinematics, be long lasting and not be difficult to revise if it fails.⁷ Initially, silicone implants were popular among surgeons and were utilized in patients who were too young and too active for joint replacement surgery.⁸

The initial reports on silastic implants showed higher rates of complication and early failure requiring revision,⁹⁻¹² leading to hesitancy among orthopaedic surgeons to continue using these implants. The current third-generation silastic implants were designed based on dynamic and static joint-specific anatomy. These have been in use since 1997 and are considered to be more durable than first- and second-generation implants.¹³ The aim of this article is to review the historical evolution and the outcomes of silastic implants for the treatment of end-stage OA of the first MTPJ.

Historical evolution of silastic implants

For surgical management of hallux rigidus, following the unsuccessful results of acrylic methacrylate implants by Endler in 1951,¹⁴ and the duralumin double-flanged design by Seeburger in 1964,¹⁵ Swanson introduced his first-generation single-stemmed silicone implants in 1967 (Dow Corning Corporation, Midland, Michigan, United States).¹⁶ He replaced the base of the proximal phalanx and used these implants as spacers in conjunction with Keller excision arthroplasty to maintain the normal weight-bearing property of the first MTPJ.¹⁶ This implant relied on the viscoelastic properties of silicone to achieve dorsiflexion. Due to the early (within four years) and high failure rates (57%) of these implants,¹⁷ Swanson designed, in 1974, a double-stemmed hinge made of silicone elastomer (second-generation) to offer a constrained design.¹⁸ Sutter also created two different designs for double-stemmed implants with 15 degrees of built-in angulation in the sagittal plane that relied on the hinge to allow dorsiflexion.^{19,20} Although early results (within three years) were promising in terms of pain improvement (69%),^{21,22} there were three main concerns identified with these implants: limited plantarflexion compromising normal propulsion during gait cycle (30%), painful plantar keratosis under the metatarsal heads (69%) and periarticular osteophytes formation (53%).²¹ Despite reports of patient satisfaction rates greater than 80% in the short term, these implants gradually started to fail because of excessive wear and the semi-constrained design.²³ Many complications with silastic prostheses emerged in the 1980s. Specifically noted complications included soft tissue inflammatory reaction simulating infection, silicone particulate synovitis, osteolysis, prosthetic wear and fragmentation with proximal migration of silicone particles causing inguinal lymphadenopathy.^{12,21,24–30} Swanson believed that sharp bony edges and excessive shearing forces caused implant wear particles, which subsequently resulted in reactive synovitis and lytic bone changes.¹⁸ This belief led to the development of bone liners, or grommets, to protect the implant from the sharp edges.³¹ Many materials, including stainless steel and cobalt chrome, were researched for this purpose; however, titanium had the most favourable interaction at the grommet–bone interface. For this reason, titanium grommets have been available for use with silastic implants since 1985 to help provide more durability to silicone implants.^{23,31–33} Despite the development of titanium grommets, reports of complications continue to surface, therefore few orthopaedic foot and ankle surgeons currently use these implants.³⁴

The concept of the design of second-generation implants was to have the metatarsal head and the base of the phalanx purchase the ground during weight bearing. However, the fact that the metatarsal head rests on the sesamoid complex and stays in an elevated position with

reference to the proximal phalanx base, was not taken into account.³⁵ The advancement of computerized technology led to the development of silicone elastomers of varying densities demonstrating better physical properties in critical areas of tensile strength and tear resistance.¹³ This became the basis of third-generation silastic implants for the first MTPJ.¹³

Currently there are three silastic double-stemmed hinge implants available: the Swanson (Wright Medical® Technology Inc., Memphis, Tennessee, United States), Primus (Futura®, Tornier Inc., Bloomington, Minnesota, United States) and Sgarlato Gait (Sgarlato® Labs Inc., San Jose, California, United States).²³ The hinge portion becomes encapsulated with collagenous tissue which helps to provide stability after the collateral ligaments are sacrificed.^{31,32} The Swanson hinge is available in sizes 0 through 7, the Primus hinge has four sizes and the Sgarlato hinge has three sizes.²³

Methodology

Search strategy

Literature search was conducted through the databases PubMed (MEDLINE), Ovid, Cochrane Library (Cochrane Systematic Reviews and Cochrane Bone, Joint and Muscle Trauma Group), Embase, ScienceDirect, Google Scholar and ISI Web of Knowledge. Articles published up to 2018 were searched but no historical time frame was applied for the start date of the search. The search was limited to articles available in the English language only.

Search terminologies

The National Library of Medicine's (NLM) Medical Subject Headings (MeSH) terms were selected and used along with text words. MeSH terms provided a consistent way to retrieve information where different terms had been used by authors for the same concept. The terminologies used included “Silastic replacement” OR “arthroplasty” OR “Swanson implant” for “first metatarsophalangeal joint” OR “big toe joint” OR “hallux rigidus”.

Inclusion criteria

All types of the articles reporting the outcomes of single- or double-stemmed silastic implants were included. In the first phase the abstracts of the relevant articles were reviewed. In the second phase full texts of selected articles were obtained from electronic databases and in hard copy format. These included the articles on single-stemmed and double-stemmed silastic replacement implants used for the first MTPJ.

Exclusion criteria

Articles reporting the outcomes of metallic implants, ceramic implants, excision arthroplasty or arthrodesis of

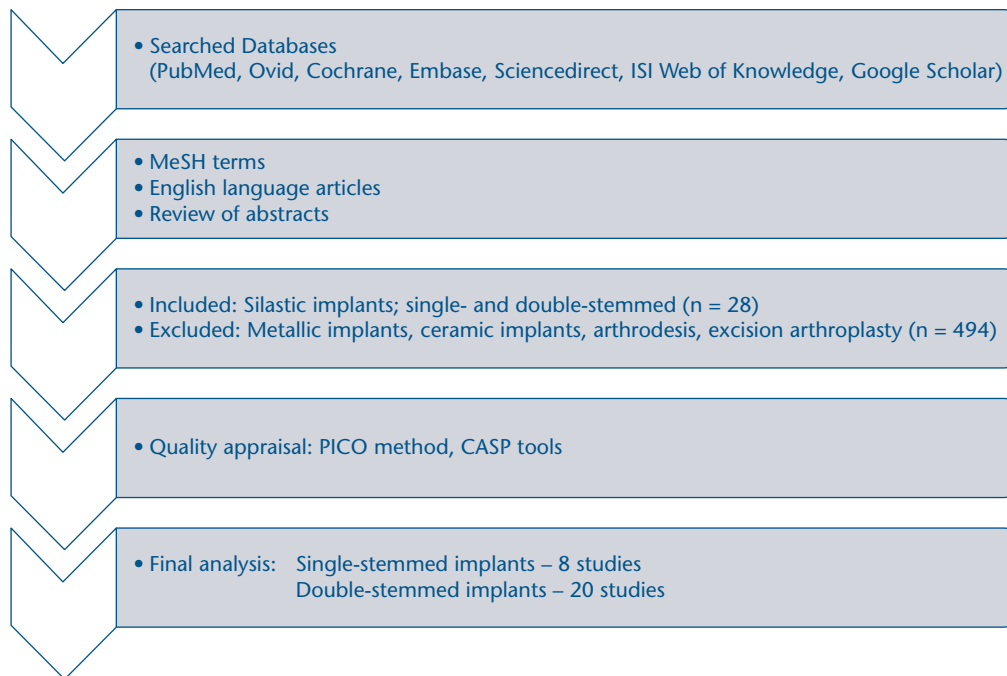


Fig. 1 Flow diagram of search methodology.

the first MTPJ were excluded. Any articles not available in the English language were excluded.

Quality appraisal

The PICO method (Population, Intervention, Comparison and Outcome) and CASP tools (Critical Appraisal Skills Programme) were used to appraise the quality of selected studies and analyse their results.^{36,37} Chi-square tests were utilized to calculate p-values. A p-value of less than 0.05 was considered significant. Figure 1 presents the summary of search methodology.

Results

The initial search revealed 522 articles from the searched databases. Twenty-eight articles were selected for final inclusion, which were most relevant to the use of silastic implants. There was only one prospective study,⁹ whilst all the others were retrospective studies. Twenty-eight studies had a total of 2354 feet with silastic replacements in 1884 patients. The studies took place and their outcome results were collected between 1968 and 2003. The average age of patients was 53 years among all the studies, the youngest patient being 15 years old and the oldest 82 years old in different studies. The average follow-up was 85.3 months. Among all the studies there were a total of 5.3% (124 feet) failed prostheses. Improvement in pain was reported in 76.6% (1804 feet). The average rate of patient satisfaction was 84%. There was a reported

incidence of 3.6% (85 feet) of superficial infection, early inflammation of the wound and synovitis. Incidence of deep infection was 1.7% (40 feet). Radiological lucencies, cyst formation, bone resorption and osteophytes formation, of varying degree, were reported in 18.2% cases (429 feet). Implant fracture and fragmentation occurred in 4.3% cases (101 feet). Eighty-four implants (3.6%) required removal due to infection, fracture or persistent pain after surgery. The length of time from surgery to implant failure or removal was found to be highly variable among different studies.

The demographic data of the studies is listed in Table 1 and the outcomes are presented in Table 2. The comparative analysis of single- and double-stemmed implants is presented in Table 3.

Discussion

Joint replacement surgery can be described as very satisfying when it goes well, and a challenging nightmare when it goes wrong. The results of silastic replacement have been quite variable because of many factors involved, including the type of implant, the patient population, the age and functional abilities of the patient, the duration of follow-up and the presence of associated deformities of the foot.³⁸ Hallux rigidus is also associated with soft tissue contracture, which limits motion. As with any joint replacement, the postoperative range of motion is correlated with the preoperative range of motion. Motion

Table 1. Characteristics of individual studies

Author(s)	Year published	Single-stem (SS) or double-stem (DS)	Study period	No. of feet	No. of patients	Average age (years)	Age range (years)	Average follow-up (months)
Swanson ¹⁶	1972	SS	1968–1971	73	55	54		
Wenger and Whalley ⁶³	1978	DS		86	69	51	20–76	24
Swanson et al ¹⁸	1979	SS	1968–1978	165	165	53	15–79	48
Swanson et al ¹⁸	1979	DS	1968–1978	105	105			30
Mölstner et al ⁵⁹	1980	SS	1972–1978	26	25	56	22–71	47
Gudmundsson and Robertsson ⁶⁰	1980	SS	1974–1976	37	29	54	22–81	64
Cracchiolo et al ⁶¹	1981	DS		159	159			45
Sethu et al ⁵¹	1980	SS		77	62	50	20–80	60
Kampner ²⁹	1984	DS	1971–1982	103	71	56	N	89
Verhaar et al ²⁷	1989	SS	1980–1985	58	43	39	17–60	59
Laird ⁶²	1990	DS	1979–1987	228	158	38	16–72	48
Shankar et al ⁵⁷	1991	DS	1982–1986	106	89			28
Granberry et al ²¹	1991	DS	1982–1986	73	52	55	23–78	
Cracchiolo et al ⁹	1992	DS	1974–1987	86	66	53	27–72	70
Moeckle et al ⁵⁰	1992	DS	1980–1985	67	45	56	36–79	72
Rahman and Fagg ³⁰	1993	SS	1980–1990	78	55			
Helal ⁴⁴	1997	DS		203	156	50	27–73	132
Lemon and Pupp ⁴⁵	1997	DS	Up to 1986	66	50	55	24–78	161
Bonet et al ⁴⁸	1997	DS	1981–1989	40	27	63	49–79	99
Ashford et al ⁶⁴	2000	DS	1994–1998	22	20	61	48–80	33
Hanyu et al ⁴³	2001	DS	1983–1990	60	39			144
Bommireddy et al ⁴⁷	2003	DS	1981–1996	42	32	64	N	96
Harrison and Loughhead ⁶⁵	2003	SS	1972–1983	13	11	52	N	212
Smetana and Vencáľková ⁴¹	2003	DS	1987–2001	108	97	50	17–82	57
Ter Keurs et al ⁴²	2011	DS	1984–2000	59	48	58	N	108
Morgan et al ⁴⁰	2012	DS	1988–2003	108	83	55	N	102
van Duijvenbode et al ⁴⁶	2013	DS	1981–1999	43	36	53	43–63	228
Kanzaki et al ⁴⁹	2014	DS	1982–1992	63	37			76

limitations can put stress on the prosthesis–bone interface and can potentially lead to failure.³⁹

The available studies primarily relate to first- and second-generation silastic implants. There were very few studies which might have included some more-recent-generation implants (launched in 1997) for their patients,^{40–42} as estimated from the study period. However, these studies did not clearly describe any change of implants after 1997. There was only one prospective study,⁹ while all the others were retrospective. This meant these studies were subject to the risk of bias in multiple domains due to missing data, lack of control over the available data, lack of control group, lost follow-up and potential difficulties for patients in recalling their pre- and postoperative symptoms due to the years since surgery. There were only four studies which presented their results with more than 10 years of average follow-up,^{43–46} seven studies had an average follow-up of more than five years,^{9,29,47–51} while the remaining 17 studies had an average follow-up of less than five years. The study with longest follow-up duration had a mean follow up of 19 years (14 to 24 years).⁴⁶ Two studies used a questionnaire-based postal follow-up,^{45,46} while all the others included a physical review of the patients using subjective and objective

measures. Comparing the single- and double-stemmed implants, there were no significant differences between the average age, the average length of follow-up, the average patient satisfaction rates and the average improvement in pain level after surgery.

The incidence of superficial infection, wound-related inflammatory changes and synovitis was found to be slightly higher with single-stemmed implants (4.4%) compared to double-stemmed implants (3.4%), but this difference was not found to be significant. There are several reports in the literature demonstrating synovial reaction to particulate silicone rubber, most commonly describing these reactions in finger implants.^{27,52–56} In addition to local inflammatory response, these studies also described a distant spread by vascular and lymphatic channels. Inflammatory response, particularly observed with single-stemmed implants, was believed to occur due to articulation of hemiarthroplasty implant with degenerated and incongruent joint surface of the metatarsal head.⁵⁶ Clinically, silicone synovitis presents as joint pain and inflammation with tender swelling of regional lymph nodes.²³ This usually requires removal of the implant, which resolves the symptoms.²⁸ The incidence of deep infection was found to be slightly higher in double-stemmed

Table 2. Outcomes of the included studies

Author(s)	Pain improved (feet) (n)	Patient satisfaction (%)	Superficial infection	Deep infection	Radiological lucencies/cysts/resorption	Implant fracture/fragmentation	Implants failed (n)	Implants revised (n)	Authors recommended
Swanson ¹⁶	73		0	0	1		0	0	Yes
Wenger and Whalley ⁶³	84	86%	11	0	6	1	1	2	Yes
Swanson et al ¹⁸	Majority		1	2	1		2	1	Yes
Swanson et al ¹⁸	105			1	0	0	1	1	Yes
Möller et al ⁵⁹	23	84%	2	1	24	0	2	2	Yes
Gudmundsson and Robertsson ⁶⁰	35	93%	14	0	34	5	2	2	Yes
Cracchiolo et al ⁶¹	159		2	2	0	1	2	1	Yes
Sethu et al ⁵¹	58	92%	5	1	2	1	1	1	Yes
Kampner ²⁹	81	79%		3		10	10	14	Yes
Verhaar et al ²⁷					34	1	49	4	No
Laird ⁶²	191	88%	6	0	2	0	3	3	Yes
Shankar et al ⁵⁷	93	88%	16	2	52	0	0	2	Yes
Granberry et al ²¹	54	74%	1	1	39	21	4	4	Use with caution
Cracchiolo et al ⁹	71	83%	5	2	32	8	4	4	Yes
Moeckle et al ⁵⁰	59	86%	3	2	6	7	3	3	Yes
Rahman and Fagg ³⁰		84%			56			3	No
Helal ⁴⁴	179	78%		14	2	6	20	20	Yes
Lemon and Pupp ⁴⁵	156	91%					0		Yes
Bonet et al ⁴⁸	34	85%	0	1	9	1	2	3	Yes
Ashford et al ⁶⁴	17	85%					1	1	Yes
Hanyu et al ⁴³		74%		2	9			4	Yes
Bommireddy et al ⁴⁷	38	75%	12	0	17	1	0	0	Yes
Harrison and Loughead ⁶⁵		85%	1	1	8	4	2	2	Yes
Smetana and Vencáľková ⁴¹	65	79%	6	2	17	6	6	1	Yes
Ter Keurs et al ⁴²	47	77%		3	30	0	3	3	Yes
Morgan et al ⁴⁰	82	85%	0	0	25	0	3	0	Yes
van Duijvenbode et al ⁴⁶	43	90%					3	3	Yes
Kanzaki et al ⁴⁹	57		0	0	23	28	0	0	Yes

implants (1.9%) compared to single-stemmed implants (0.95%) ($p > 0.05$). The reported incidence of silicone synovitis varies between 0% and 26% in different studies; however, it does not always necessitate removal of the implant.^{9,47,57,58}

The incidence of radiological changes around the implants (lucent areas, cysts, resorption and osteophyte formation) was found to be significantly higher in patients with single-stemmed implants (30.3%) compared to the double-stemmed implants (14.7%) ($p < 0.05$). It is important to note that these changes do not necessarily correlate with patients' subjective satisfaction.^{9,30,40,42,49,57,59,60} It is believed that satisfactory function continues even after radiographic deterioration because the implant acts as a spacer via encapsulation rather than a fixed hinge.⁴⁰ It is considered as the body's response to surgical intervention with the implant serving as a template for the proper deposition and alignment of encapsulating collagen tissues.^{9,61}

The double-stemmed implants suffered from more fractures and fragmentations (4.9%) than the single-stemmed implants (2%) ($p < 0.05$). The incidence of implant fracture has been reported as between 1% and 11% in different studies,^{16,21,22,49} however, implant fracture is not necessarily associated with a poor outcome. Significantly more single-stemmed implants failed (11%)

than the double-stemmed implants (3.6%) ($p < 0.05$). However, the failed implants that required removal or revision were comparable in the two groups. This was due to the patients with low level of symptoms or not wishing to undergo any further surgery and can possibly be explained by the encapsulation mechanism described above. High frequency of implant failure was found to be related to the length of time the implant had been in place (four years or more).^{21,51}

The authors of two studies recommended discontinuing the use of these silastic implants due to higher failure rates and significant complications.^{27,30} Both studies used single-stemmed implants. Another study recommended the use of double-stemmed silastic implants 'with caution' in selected patients.²¹ The authors of all the other studies recommended to continue using silastic implants as they provided higher satisfaction and improvement in pain levels related to hallux rigidus. However, a general consensus among most of the authors was to avoid using them in younger patients and those with higher physical demands to avoid early failure.^{27,42,45,47,48,60}

Three studies assessed the use of titanium grommets with double-stemmed implants.^{42,46,49} Two of these studies reported a higher incidence of radiological lucencies and implant failure without the use of grommets and

Table 3. Comparative analysis of single- and double-stemmed implants

Outcomes	Single-stemmed implants [n (%)]	Double-stemmed implants [n (%)]
No. of studies	8	20
Study period	1968–1983	1974–2003
No. of feet	527	1827
No. of patients	445	1439
Average age (years)	51 (15–80)	54.4 (16–82)
Average follow-up (months)	81.6	86.4
Improvement in pain	88.7%	88.4%
Average patient satisfaction	87.6%	82.5%
Superficial infection	23.0 (4.4%)	62.0 (3.4%)
Deep infection	5.0 (0.9%)	35.0 (1.9%)
Radiological lucencies/cysts/ resorption/osteophytes	160.0 (30.3%)	269.0 (14.7%) (p < 0.05)
Implant fracture/fragmentation	11.0 (2%)	90.0 (4.9%) (p < 0.05)
Prostheses failed	58.0 (11%)	66.0 (3.6%) (p < 0.05)
Prostheses removed	15.0 (2.9%)	69.0 (3.8%)

recommended that they be used routinely,^{42,49} while the third study did not find any significant differences in the outcomes of implants with or without the use of grommets.⁴⁶

During the early years, silastic implants were also used to treat degenerative first MTPJ problems associated with hallux valgus deformity. Studies that reviewed the results of these patients reported initial improvement in pain and deformity correction but a higher incidence of subsequent recurrence of hallux valgus deformity.^{16,18,30,51,60,62,63} Therefore the use of silastic implants for treating hallux valgus deformity was not recommended.

This article is an effort to provide a systematic review of the available literature on the outcomes of silastic implants including very early reported studies. To the author’s knowledge there is no such review available in the literature. The strengths include a detailed analysis of the currently reported and historical studies utilizing appropriate critical appraisal tools. The author believes that the results of this review will provide surgeons with a detailed account of the results and initial complications related to the design of the implants and a forward direction to conduct future studies. The weaknesses of this review include the fact that the available studies provided are only Level-IV evidence. Furthermore, these studies were analysed by only one author. However, with the use of relevant research tools, sufficient data were extracted and have been presented in a logical manner.

Conclusion

The available studies have shown that the silastic joint replacement can be a good alternative to arthrodesis in older and less active patients who wish to preserve the movements of their first metatarsophalangeal joint. Several historical studies have reported high satisfaction rates and subjective and objective improvements for treating hallux rigidus with the use of previous generations of silastic implants but were fraught with implant-related

complications, in particular with the use of single-stemmed implants. Most of the available studies have smaller patient populations, shorter follow-up and flaws in study designs with a few reporting long-term results of the older implants for relatively larger numbers of patients. There is a lack of long-term follow-up of the current implants in the literature. Some of the implants in current use have no published results. More long-term prospective and randomized controlled studies with larger patient cohorts are needed to build a robust evidence base for the use of current generation of silastic implants as an alternative to the traditional arthrodesis procedure.

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REFERENCES

1. van Saase JL, van Romunde LK, Cats A, Vandenbroucke JP, Valkenburg HA. Epidemiology of osteoarthritis: zoetermeer survey. Comparison of radiological

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- osteoarthritis in a Dutch population with that in 10 other populations. *Ann Rheum Dis* 1989;48:271–280.
2. **DeFrino PF, Brodsky JW, Pollo FE, Crenshaw SJ, Beischer AD.** First metatarsophalangeal arthrodesis: a clinical, pedobarographic and gait analysis study. *Foot Ankle Int* 2002;23:496–502.
 3. **Perler AD, Nwosu V, Christie D, Higgins K.** End-stage osteoarthritis of the great toe/hallux rigidus: a review of the alternatives to arthrodesis: implant versus osteotomies and arthroplasty techniques. *Clin Podiatr Med Surg* 2013;30:351–395.
 4. **Deland JT, Williams BR.** Surgical management of hallux rigidus. *J Am Acad Orthop Surg* 2012;20:347–358.
 5. **Lau JT, Daniels TR.** Outcomes following cheilectomy and interpositional arthroplasty in hallux rigidus. *Foot Ankle Int* 2001;22:462–470.
 6. **McKeever DC.** Arthrodesis of the first metatarsophalangeal joint for hallux valgus, hallux rigidus, and metatarsus primus varus. *J Bone Joint Surg [Am]* 1952;34-A:129–134.
 7. **Peace RA, Hamilton GA.** End-stage hallux rigidus: cheilectomy, implant, or arthrodesis? *Clin Podiatr Med Surg* 2012;29:341–353.
 8. **Vanore J, O'Keefe R, Pikscher I.** Silastic implant arthroplasty: complications and their classification. *J Am Podiatry Assoc* 1984;74:423–433.
 9. **Cracchiolo A III, Weltmer JB Jr, Lian G, Dalseth T, Dorey F.** Arthroplasty of the first metatarsophalangeal joint with a double-stem silicone implant: results in patients who have degenerative joint disease failure of previous operations, or rheumatoid arthritis. *J Bone Joint Surg [Am]* 1992;74:552–563.
 10. **Freedman AS, Takvorian T, Neuberg D, et al.** Autologous bone marrow transplantation in poor-prognosis intermediate-grade and high-grade B-cell non-Hodgkin's lymphoma in first remission: a pilot study. *J Clin Oncol* 1993;11:931–936.
 11. **McNearney T, Haque A, Wen J, Lisse J.** Inguinal lymph node foreign body granulomas after placement of a silicone rubber (Silflex) implant of the first metatarsophalangeal joint. *J Rheumatol* 1996;23:1449–1452.
 12. **Sammarco GJ, Tabatowski K.** Silicone lymphadenopathy associated with failed prosthesis of the hallux: a case report and literature review. *Foot Ankle* 1992;13:273–276.
 13. **DeCarbo WT, Lupica J, Hyer CF.** Modern techniques in hallux rigidus surgery. *Clin Podiatr Med Surg* 2011;28:361–383.
 14. **Endler F.** Development of a prosthetic arthroplasty of the head of the first metatarsal bone, with a review of present indications. *Z Orthop Ihre Grenzgeb* 1951;80:480–487.
 15. **Seeburger RH.** Surgical implants of alloyed metal in joints of the feet. *J Am Podiatry Assoc* 1964;54:391–396.
 16. **Swanson AB.** Implant arthroplasty for the great toe. *Clin Orthop Relat Res* 1972;85:75–81.
 17. **Ris HB, Mettler M, Engeloeh F.** Long-term results using a Swanson silastic endoprosthesis of the metatarsophalangeal joint of the great toe: discrepancy between clinical and radiologic findings. *Z Orthop Ihre Grenzgeb* 1988;126:526–529.
 18. **Swanson AB, Lumsden RM, Swanson GD.** Silicone implant arthroplasty of the great toe: a review of single stem and flexible hinge implants. *Clin Orthop Relat Res* 1979;142:30–43.
 19. **LaPorta GA, Pilla P Jr, Richter KP.** Keller implant procedure: a report of 536 procedures using a silastic intramedullary stemmed implant. *J Am Podiatry Assoc* 1976;66:126–147.
 20. **Lawrence BR, Papier MJ II.** Implant arthroplasty of the lesser metatarsophalangeal joint: a modified technique. *J Foot Surg* 1980;19:16–18.
 21. **Granberry WM, Noble PC, Bishop JO, Tullos HS.** Use of a hinged silicone prosthesis for replacement arthroplasty of the first metatarsophalangeal joint. *J Bone Joint Surg [Am]* 1991;73:1453–1459.
 22. **Kampner SL.** Long-term experience with total joint prosthetic replacement for the arthritic great toe. *Bull Hosp Jt Dis Orthop Inst* 1987;47:153–177.
 23. **Fadel GE, Abboud RJ, Rowley DI.** Implant arthroplasty of the hallux metatarsophalangeal joint. *Foot* 2002;12:1–9.
 24. **Patel DC, Frascone ST, DeLuca A.** Synovitis secondary to silicone elastomeric joint implant. *J Foot Ankle Surg* 1994;33:628–632.
 25. **Freed JB.** The increasing recognition of medullary lysis, cortical osteophytic proliferation, and fragmentation of implanted silicone polymer implants. *J Foot Ankle Surg* 1993;32:171–179.
 26. **Johnson KA, Saltzman CL.** Complications of resection arthroplasty (Keller) and replacement arthroplasty (silicone) procedures. *Contemp Orthop* 1991;23:139–147.
 27. **Verhaar J, Vermeulen A, Bulstra S, Walenkamp G.** Bone reaction to silicone metatarsophalangeal joint-1 hemiprosthesis. *Clin Orthop Relat Res* 1989;245:228–232.
 28. **Shiel WC Jr, Jason M Jr.** Granulomatous inguinal lymphadenopathy after bilateral metatarsophalangeal joint silicone arthroplasty. *Foot Ankle* 1986;6:216–218.
 29. **Kampner SL.** Total joint prosthetic arthroplasty of the great toe: a 12-year experience. *Foot Ankle* 1984;4:249–261.
 30. **Rahman H, Fagg PS.** Silicone granulomatous reactions after first metatarsophalangeal hemiarthroplasty. *J Bone Joint Surg [Br]* 1993;75:637–639.
 31. **Swanson AB, de Groot Swanson G, Ishikawa H.** Use of grommets for flexible implant resection arthroplasty of the metatarsophalangeal joint. *Clin Orthop Relat Res* 1997;342:22–33.
 32. **Swanson AB, de Groot Swanson G, Maupin BK, et al.** The use of a grommet bone liner for flexible hinge implant arthroplasty of the great toe. *Foot Ankle* 1991;12:149–155.
 33. **Furikado K, Fujioka H, Doita M, et al.** Use of grommet for Swanson flexible hinge toe implant arthroplasty for hallux valgus deformity of rheumatoid arthritis. *Ryumachi* 2002;42:879–884.
 34. **Esway JE, Conti SF.** Joint replacement in the hallux metatarsophalangeal joint. *Foot Ankle Clin* 2005;10:97–115.
 35. **Coughlin MJ, Shurnas PS.** Hallux rigidus: grading and long-term results of operative treatment. *J Bone Joint Surg [Am]* 2003;85-A:2072–2088.
 36. **Huang X, Lin J, Demner-Fushman D.** Evaluation of PICO as a knowledge representation for clinical questions. *AMIA Annu Symp Proc* 2006;359–363.
 37. **Nadelson S, Nadelson LS.** Evidence-based practice article reviews using CASP tools: a method for teaching EBP. *Worldviews Evid Based Nurs* 2014;11:344–346.
 38. **Shereff MJ, Baumhauer JF.** Hallux rigidus and osteoarthritis of the first metatarsophalangeal joint. *J Bone Joint Surg [Am]* 1998;80:898–908.
 39. **Erdil M, Elmadağ NM, Polat G, et al.** Comparison of arthrodesis, resurfacing hemiarthroplasty, and total joint replacement in the treatment of advanced hallux rigidus. *J Foot Ankle Surg* 2013;52:588–593.
 40. **Morgan S, Ng A, Clough T.** The long-term outcome of silastic implant arthroplasty of the first metatarsophalangeal joint: a retrospective analysis of one hundred and eight feet. *Int Orthop* 2012;36:1865–1869.
 41. **Smetana M, Vencáľková S.** Use of a silicone metatarsophalangeal joint endoprosthesis in hallux rigidus over a 15-year period. *Acta Chir Orthop Traumatol Cech* 2003;70:177–181.

- 42. Ter Keurs EW, Wassink S, Burger BJ, Hubach PC.** First metatarsophalangeal joint replacement: long-term results of a double stemmed flexible silicone prosthesis. *Foot Ankle Surg* 2011;17:224–227.
- 43. Hanyu T, Yamazaki H, Ishikawa H, et al.** Flexible hinge toe implant arthroplasty for rheumatoid arthritis of the first metatarsophalangeal joint: long-term results. *J Orthop Sci* 2001;6:141–147.
- 44. Helal B.** A long-term review of replacements of the great toe metatarsophalangeal joint using a bitemmed silicone elastomer ball-shaped spacer. *Foot* 1997;7:61–67.
- 45. Lemon B, Pupp GR.** Long-term efficacy of total SILASTIC implants: a subjective analysis. *J Foot Ankle Surg* 1997;36:341–346.
- 46. van Duijvenbode DC, Bulstra GH, Nijse BA.** Nineteen-year follow-up of the silastic double stemmed hinge prosthesis of the first metatarsophalangeal joint. *Foot Ankle Surg* 2013;19:27–30.
- 47. Bommireddy RS, Singh SK, Sharma P, et al.** Long-term follow-up of silastic joint replacement of the first metatarsophalangeal joint. *Foot* 2003;13:151–155.
- 48. Bonet J, Taylor DT, Lam AT, Williams E, Keane LA.** Retrospective analysis of silastic implant arthroplasty of the first metatarsophalangeal joint. *J Foot Ankle Surg* 1998;37:128–134.
- 49. Kanzaki N, Nishiyama T, Fujishiro T, et al.** Flexible hinge silicone implant with or without titanium grommets for arthroplasty of the first metatarsophalangeal joint. *J Orthop Surg (Hong Kong)* 2014;22:42–45.
- 50. Moeckel BH, Sculco TP, Alexiades MM, et al.** The double-stemmed silicone-rubber implant for rheumatoid arthritis of the first metatarsophalangeal joint: long-term results. *J Bone Joint Surg [Am]* 1992;74:564–570.
- 51. Sethu A, D’Netto DC, Ramakrishna B.** Swanson’s silastic implants in great toes. *J Bone Joint Surg [Br]* 1980;62-B:83–85.
- 52. Aptekar RG, Davie JM, Cattell HS.** Foreign body reaction to silicone rubber: complication of a finger joint implant. *Clin Orthop Relat Res* 1974;98:231–232.
- 53. Christie AJ, Weinberger KA, Dietrich M.** Silicone lymphadenopathy and synovitis: complications of silicone elastomer finger joint prostheses. *JAMA* 1977;237:1463–1464.
- 54. Ferlic DC, Clayton ML, Holloway M.** Complications of silicone implant surgery in the metacarpophalangeal joint. *J Bone Joint Surg [Am]* 1975;57:991–994.
- 55. Gordon M, Bullough PG.** Synovial and osseous inflammation in failed silicone-rubber prostheses. *J Bone Joint Surg [Am]* 1982;64:574–580.
- 56. Worsing RA Jr, Engber WD, Lange TA.** Reactive synovitis from particulate silastic. *J Bone Joint Surg [Am]* 1982;64:581–585.
- 57. Shankar NS, Asaad SS, Craxford AD.** Hinged silastic implants of the great toe. *Clin Orthop Relat Res* 1991;272:227–234.
- 58. Sollitto RJ, Shonkweiler W.** Silicone shard formation: a product of implant arthroplasty. *J Foot Surg* 1984;23:362–365.
- 59. Mölster AO, Lunde OD, Rait M.** Hallux rigidus treated with the Swanson silastic hemi-joint prosthesis. *Acta Orthop Scand* 1980;51:853–856.
- 60. Gudmundsson G, Robertsson K.** Silastic arthroplasty of the first metatarsophalangeal joint. *Acta Orthop Scand* 1980;51:575–578.
- 61. Cracchiolo A III, Swanson A, Swanson GD.** The arthritic great toe metatarsophalangeal joint: a review of flexible silicone implant arthroplasty from two medical centers. *Clin Orthop Relat Res* 1981;157:64–69.
- 62. Laird L.** Silastic joint arthroplasty of the great toe: a review of 228 implants using the double-stemmed implant. *Clin Orthop Relat Res* 1990;255:268–272.
- 63. Wenger RJ, Whalley RC.** Total replacement of the first metatarsophalangeal joint. *J Bone Joint Surg [Br]* 1978;60:88–92.
- 64. Ashford RL, Vogiatzoglou F, Tollafield DR, Cassella JP.** A retrospective analysis of Swanson Silastic® double-stemmed great toe implants with titanium grommets following podiatric surgery for arthritic joint disease. *Foot* 2000;10:69–74.
- 65. Harrison WJ, Loughhead JM.** Silastic metatarsophalangeal arthroplasty: very long-term results of single-stem implants in degenerative joint disease. *Foot* 2003;13:146–150.