IMPLANTS: TOTAL VS. HEMI

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INTRODUCTION

First metatarsophalangeal joint implant arthroplasty has been performed at Doctors Hospital for the past 30 years. In certain instances the silastic implants have been very successful in providing greater pain free motion of the joint (MPJ), and in turn, allowing the patient to walk with less difficulty. Joint implants are generally considered as spacers and do not act functionally. They do, however, increase the range of motion substantially in most cases.

What are the specific indications, contraindications, and complications of the hemi and the total silastic implants? In what situations should the surgeon choose a hemi-implant over a total implant? We will attempt to answer these questions as well as present the planning and preliminary results of a retrospective study comparing the two types of first metatarsophalangeal joint implants.

PURPOSE

The purpose of this study is to discuss the factors that contribute to successful implant arthroplasty of the first MPJ. The inherent advantages of the hemi over the total implant is presented. The specific purpose is to test the validity of the assumption that the implant functions mainly as a joint spacer and must not be depended on to accomplish restoration of motion or correction of deformity.

The study is divided into two phases and the paper will present the preliminary results. Phase one is a physician's survey to demonstrate the experiences of surgeons at the Podiatry Institute. Each physician's responses and comments were confidential and were used in combination with other responses for statistical purposes only. The preliminary results of this study is included herein.

Phase two is a ten year retrospective study consisting of a random sampling of 150 patients out of over 1,000 patients who underwent implant arthroplasty of the first MPJ. The preliminary results will be presented at the Atlanta meeting in the spring of 1989 as a basis for further investigation.

HISTORY

In order to better appreciate first metatarsophalangeal joint implant arthroplasty a brief historical review of the literature pertaining to implant indications and their use is necessary.

First metatarsophalangeal joint implants are indicated in a variety of situations. Implants are indicated when there are clinical or radiological signs of degeneration of joint surfaces of either the base of the proximal phalanx or the head of the first metatarsal. This can obviously occur in hallux rigidus, hallux valgus, hallux varus, rheumatoid arthritis, osteoarthritis, and any other disease or traumatic process capable of damaging joint cartilage.

Many attempts to correct the arthritic joint have been cited in the literature. Heubach in 1897 first introduced the idea of relaxing the joint impingement by resection of all or part of the first metatarsophalangeal joint (1). In 1904, Keller introduced a procedure which is still popular today. He described the resection of a part of the base of the proximal phalanx (2). Mayo and Stone have described procedures that resect the head of the first metatarsal. These procedures have been complicated by shortening of the hallux, instability of the hallux, lesser metatarsalgia, and improper joint alignment.

Implants were first introduced as treatment for arthritic first metatarsophalangeal joint deformities (hallux rigidus, hallux valgus, hallux varus) in 1951 when Endler introduced an acrylic implant to be placed in the base of the proximal phalanx as an adjunct to a Keller procedure (3). In 1956 Sieffert placed a nylon spacer between the base of the proximal phalanx and the first metatarsal head (4). These and other attempts failed due to bioincompatibility.

In 1967 Swanson introduced silicone implants to be used at the metacarpophalangeal joints of the hand and the first metatarsophalangeal joints of the foot. The silicone is a high performance medical grade specifically developed for use as flexible joint implants (5). Silicone is an inert material which had proven in clinical studies to be biocompatible.

The hemi-implant introduced by Swanson serves as an interpositional spacer to be used as an adjunct to the Keller arthroplasty procedure. It serves as the base of the proximal phalanx and consists of two parts: base (collar) and the medullary stem (Fig. 1). The base is ovoid in shape, the width (medial to lateral) being greater than its height (dorsal to plantar). The intra-articular surface is concave to fit the head of the first metatarsal. The implant is produced by Dow Corning Co. and is marketed in five sizes. The Swanson hemi-implant is the most commonly used hemi-implant at our Institution and will therefore be the subject of our retrospective study.

Weil modified the Swanson hemi-implant in the late 1970's when he accounted for an abnormal proximal articular set angle. A 15 degree lateral flare was added to the implant to accommodate for a resultant lateral gap when the toe was straightened.

Swanson introduced a double stemmed silicone implant in 1977 for those joints which had severe arthritic changes in the head of the first metatarsal (Fig. 2). The implant is also produced by Dow Corning and is marketed in eight sizes. There is no angulation in either the transverse or sagittal plane. The implant allows for dorsiflexion with a U-shaped hinge. This implant is also used quite extensively at our Institution.

Attempts have been made to improve on the hemi and total silastic implants. Sutter introduced the LaPorta and Lawrence total implant designs. These appear as modified versions of the Swanson total implant which increase the range of motion and accommodate for deforming forces by angulating the stems in the transverse and sagittal planes. Swanson claimed that there was 60 degrees of motion at the metatarsophalangeal joint after total joint implantation. Studies performed by LaPorta and Barry have indicated that motion is somewhat less.

LaPorta and Lawrence report ranges of motion of 60 degrees or greater. Their implants consist of an H-shaped hinge instead of the U-shaped. This purports to allow for greater range of motion. Both of the designs are angled 15 degrees in the sagittal plane thus accomodating for the first metatarsal declination angle. The LaPorta implant is marketed in a right, left, and neutral design, deviating the left and the right by ten degrees in the transverse plane. The Lawrence implant is only produced in a neutral design. In the Lawrence design the hinge is elongated dorsally and angulated inferiorly so that the insertion of the flexor hallucis brevis remains intact. He allowed for angular cutting of the phalangeal base to preserve the tendinous insertion (6).

INDICATIONS FOR IMPLANT ARTHROPLASTY

Implant arthroplasty is indicated when there is significant arthritic deterioration and joint narrowing at the first metatarsophalangeal joint and in which instance a Keller procedure is an option. These circumstances can be present in hallux limitus or rigidus, hallux abducto valgus, or hallux varus deformity. Any situation which results in instability or painful restriction of motion may provide an indication. Severe subluxation and lateral deviation of the proximal phalanx with subchondral bone changes are also good indications for joint implant arthroplasty. Painful range of motion with joint crepitus noted on physical exam reinforce the need for implants.

Hemi implants are indicated when there is significant degenerative change on the base of the proximal phalanx and mild change on the head of the first metatarsal. This can be appreciated in Figure 3. There are many instances when radiologic evaluation indicates significant degeneration of the metatarsal head. Yet, after resection of osteophytic lipping and cleaning the joint of debris, the head of the metatarsal may show only mild degenerative change. In these situations hemi implants are appropriate.

Total implants are indicated in those instances where there is significant subchondral bone degeneration on both sides of the joint as can be seen in Figure 4. At our Institution total silastic implants are used in combination with a pan metatarsal head resection so that the metatarsal parabola is maintained.

GOALS OF SUCCESSFUL IMPLANT ARTHROPLASTY

The primary goal is relief of pain. Implant arthroplasty can accomplish this by removal of the joint and replacement by a spacer to prevent shortening of the hallux.

Motion is restored to the joint as previously mentioned. Total hinge implants provide greater motion as compared to hemi implants.

It is important to reduce any deformity that is present. In some instances additional osseous correction is necessary to reduce the deforming force. This may involve such combinations of surgery as a base wedge osteotomy along with a total first metatarsophalangeal joint implant arthroplasty.

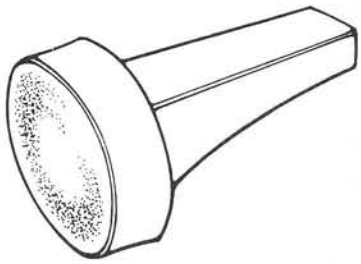

Fig. 1. Swanson hemi silicone implant produced by Dow Corning Pharmaceutical Co.

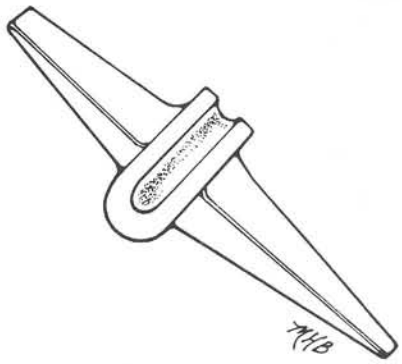

Fig. 2. Swanson double stemmed silicone implant produced by Dow Corning Pharmaceutical Co.

CONTRAINDICATIONS FOR IMPLANT ARTHROPLASTY

There are several contraindications to implant arthroplasty which must be considered. Peripheral neuropathy prevents adequate proprioception and pain sensation which are desirable for successful implant arthroplasty. The performance of implant procedures in such patients has led to destruction of the implant and the joint in a process similar to that seen in a charcot joint (6).

The procedures are contraindicated in osteoporotic bone for obvious reasons. The soft bone in these patients may not support an implant and bone erosion or collapse of the joint can result (6).

Historically implant procedures have been of questionable value in young individuals with a high activity level. Alternative joint sparing procedures should be attempted where possible. In addition, the procedures should not be performed in patients with an active growth center at the head of the metatarsal and base of the proximal phalanx. This would obviously result in stunting growth of the first ray (6).

Previous history of infection at the joint is also a contraindication. Recent evidence supports reimplantation with the appropriate selection of cases and with antibiotic coverage. This, however, has been largely observed in large joints (6).

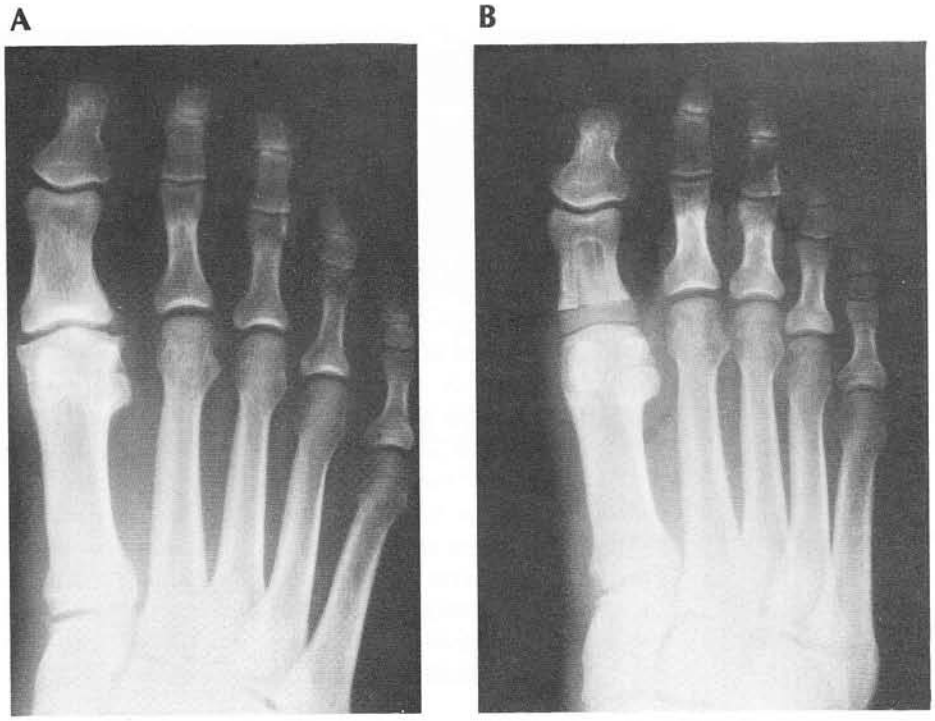

Fig. 3. First metatarsophalangeal joint arthroplasty with insertion of Swanson silastic hemi implant. A. Preoperative and B. Postoperative x-rays.

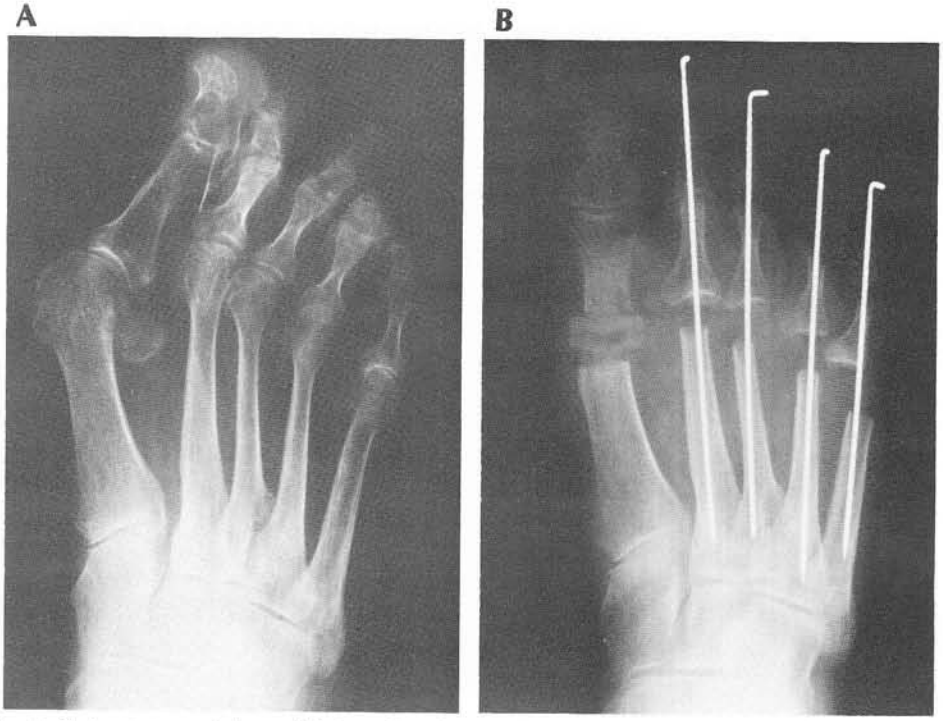

Fig. 4. First metatarsophalangeal joint arthroplasty with insertion of Swanson silastic total implant. A. Preoperative and B. postoperative x-rays.

COMPLICATIONS

A Variety of complications have been reported with silastic implants in general and specifically with hemi and total implant arthroplasty. Vanore et al classified the complications into two categories: intrinsic and extrinsic.

Intrinsic failure of the implant refers to the failure of inherent physical properties of the implant itself such as fatigue fractures.

Extrinsic failure of the implant refers to those problems associated with the tampering or injudicious use of the implant (6). This is divided into alignment abnormalities, adjacent bone abnormalities (aseptic necrosis, ectopic bone formation), soft tissue abnormalities (reactions to silicone), and biomechanical joint failure (surgical technique error and failure inherent to the joint arthroplasty) (7). The complications of biomechanical joint failure relate to the discussion of complications associated with hemi vs. total implants.

Hallux extensus is a relatively common complication and is observed in both the hemi and total silastic implants. Caneva et al reported hallux extensus as the most frequently seen complication (8). Inadequate repair of the insertion of flexor hallucis brevis, laceration of flexor hallucis longus tendon, and extensor hallucis contracture predispose the patient to this complication.

Complications associated most specifically with hemi implants stem from the transverse instability inherent to this arthroplastic procedure. They are most commonly observed when using the implant arthroplasty to correct hallux valgus. If the deforming forces (intermetatarsal angle, proximal articular set angle) have not been neutralized, bending forces are created. If the intermetatarsal (IM) angle is excessive stress is created at implant collar and stem interface which can result in dislocation or deformation of the implant. Insertion of a hemi implant into a joint with an abnormally high proximal articular set angle (PASA) creates gaping of the lateral aspect of the joint. This can be observed on x-ray as a lateral gap sign, meaning joint wedging at the lateral aspect of the head of the metatarsal and the articular surface of the implant. An aggressive medial capsulorraphy can aggravate this problem.

Complications most commonly observed with total silastic implant primarily stem from excessive resection of the head of the first metatarsal and instability of the joint complex if the flexor apparatus is not reattached. Excessive resection of the head of the metatarsal lessens the purchasing power of first ray and places stress on the lesser metatarsals causing lesser metatarsalgia.

SURGICAL PROCEDURES: HEMI AND TOTAL IMPLANT ARTHROPLASTY

The following surgical procedures should be performed with strict attention to anatomical dissection. This will allow the surgeon to systematically dissect the first metatarsophalangeal joint and identify pathological anatomy. It will also permit preservation of normal anatomical relationships and prevention of hematoma which can invite infection.

HEMI IMPLANT ARTHROPLASTY

Attention is first directed to the dorsomedial aspect of the first metatarsophalangeal joint where a curvilinear incision is placed. The incision is deepened through the superficial fascia to the deep fascia, being careful to maintain adequate surgical hemostasis by clamping, coagulating, or ligating bleeders as necessary. At the level of the deep fascia the natural cleavage plane between the superficial fascia and deep fascia is separated medially, dorsally, and laterally down into the interspace.

Dissection is then directed to the first intermetatarsal space where the deep transverse intermetatarsal ligament is transected. The insertion of the adductor tendon into the fibular sesamoid and the base of the proximal phalanx is identified. The tendon is sharply dissected from its insertion and tagged for later transfer. The fibular sesamoidal ligament is identified and suspended with a freer elevator and transected. Passive range of motion is then performed to determine whether adequate plantar lateral release has been accomplished. If no further release of the fibular sesamoid is warranted, the procedure is continued. However, if further release is indicated a fibular sesamoidectomy may be performed.

Attention is then directed to the medial capsule where an inverted *L*shaped capsulotomy is performed extending onto the base of the proximal phalanx. The capsule and periosteal tissue is dissected from the head of the first metatarsal and the base of the proximal phalanx. The prominent dorsomedial eminence is resected with an osteotome and mallet. Any dorsal osteophytic projections are removed with a rongeur and smoothed with a power burr. The wound is flushed with sterile normal saline.

Attention is next directed to the base of the proximal phalanx. Subcapsular and subperiosteal dissection is performed to free all soft tissue attachments. The proximal third of the base of the proximal phalanx is resected. The medullary canal is then opened with a probe which is followed by the appropriate broaches. After preparation of the canal, implant sizers are used to determine the appropriate size. The collar size should be wider than the cortex to prevent ectopic bone formation around the implant collar.

Once the appropriate implant size has been determined one drill hole is placed at the plantar aspect of the base of the proximal phalanx for reattachment of the flexor hallucis brevis and two drill holes are placed at the dorsomedial and plantar-medial corners of the phalanx for insertion of the medial capsule. The sutures are then placed but allowed to remain untied.

The plantar suture securing the flexor hallucis brevis to the plantar drill hole is tied. The implant is then placed into the proximal phalanx and the medial suture drawn tight and tied. An adductor tendon transfer is then performed if indicated using 2-0 dexon. The remainder of the dorsal arm of the capsule is re-approximated with 3-0 dexon.

Superficial fascia is usually closed with 4-0 dexon and skin with 5-0 dexon subcuticular sutures.

TOTAL SILASTIC IMPLANT ARTHROPLASTY

The surgical technique for the insertion of the total silastic implant is identical to that of the hemi implant except for preparation of the distal end of the metatarsal. The distal aspect of the metatarsal head is resected and a canal prepared to receive the proximal stem of the implant.

The general guidelines recommend a minimal 3 mm resection of bone from the distal aspect of the first metatarsal and an 8 mm resection of the base of the proximal phalanx. Additional bone may be resected in order to maintain the appropriate weight-bearing parabola if indicated (9).

The resection of the base of the proximal phalanx and the distal head of the first metatarsal is made perpendicular to the long axis of the respective bones if the intermetatarsal (IM) angle is relatively low. If the IM angle is increased, the resection must be angled laterally in order to avoid creating deforming forces. This prevents bending forces on the implant which can result in failure of the implant.

Specific sizers are used for the total implants. The width of the implant chosen depends on the width of the base of the proximal phalanx and the head of the metatarsal. The width of the hinge is slightly larger than the widest bone.

After the selection of the appropriate implant, it is placed into the resected joint and the capsule closed as was described in the preceding procedure. The flexor

brevis tendon is inserted into the base of the proximal phalanx to help stabilize the first metatarsophalangeal joint and avoid hallux extensus.

RESULTS

The following responses to questions concerning implant arthroplasty of the first metatarsophalangeal joint demonstrate the experiences of surgeons at the Podiatry Institute. Each surgeon was given an opportunity to comment on factors that are necessary in providing successful implantation of the first metatarsophalangeal joint. These comments are summarized. Each surgeon rated their responses and the results that follow are based on percentages.

IMPLANTS OF FIRST METATARSOPHALANGEAL JOINT

1 = Strongly agree 2 = Agree 3 = Neutral 4 = Disagree
5 = Strongly disagree NA = Not applicable/don't know

	1	2	3	4	5	NA
A. The implant itself in implant arthroplasty functions mainly as a joint spacer and must not be depended upon for correction of the deformity	65%	35%	0%	0%	0%	0%
B. In most cases the hemi implant is preferred over the total implant	30%	25%	10%	30%	5%	0%
C. More postoperative complications are noted with the total implant in comparison to the hemi implant	0%	20%	55%	20%	5%	0%
D. Anatomic dissection and proper tissue handling contributes to successful implantation	70%	30%	0%	0%	0%	0%
E. Muscle-tendon balancing techniques are essential in providing successful implantation	50%	40%	5%	5%	0%	0%
F. Structural realignment of the first metatarsal is important in establishing motion and obtaining correction of the deformity	55%	45%	0%	0%	0%	0%
G. Peripheral neuropathy is a contraindication for implant arthroplasty	35%	25%	10%	3%	0%	27%
H. Advanced osteoporosis is a contraindication for implant arthroplasty	35%	50%	10%	5%	0%	0%
I. The younger or athletic patient is a contraindication for implant arthroplasty	25%	45%	25%	5%	0%	0%
J. Previous history of infection at the implant site is a contraindication for implant arthroplasty	15%	35%	40%	10%	0%	0%
K. Implant arthroplasty is more commonly performed in the female patient in comparison to the male patient	0%	30%	60%	10%	0%	0%
L. The patients' foot type has a direct relationship to the success of implant arthroplasty	10%	55%	35%	0%	0%	0%
M. Total implant arthroplasty should be reserved for those cases where joint destruction is present on the base of the proximal phalanx and also the head of the first metatarsal	20%	55%	10%	15%	0%	0%
N. Hemi implants should not be used when there is mild to moderate degeneration of the head of the first metatarsal	0%	40%	35%	25%	0%	0%
O. The indications for the hemi implant are the same indications as for the total implant	0%	15%	10%	40%	35%	0%
P. Implant failure can be related to the implant design primarily and not to the surgical indications or technique	0%	0%	20%	40%	40%	0%
Q. Structural realignment of the first metatarsal with metatarsal osteotomy is essential in obtaining correction of the deformity	20%	45%	15%	20%	0%	0%

The following is a summary of the results of the majority of surgeons surveyed at our Institution.

1. 100% of the respondents strongly agreed or agreed that the implant itself in implant arthroplasty functions mainly as a joint spacer and must not be depended upon for correction of the deformity.
2. Over 55% of those surveyed indicated that in most cases the hemi implant is preferred over the total implant.
3. 100% strongly agreed or agreed that anatomic dissection and proper tissue handling contributes to successful implantation.
4. 90% strongly agreed or agreed that muscle-tendon balancing techniques are essential in providing successful implantation.
5. 100% strongly agreed or agreed that structural realignment of the first metatarsal is important in establishing motion and obtaining correction of the deformity.
6. 60% strongly agreed or agreed that peripheral neuropathy is a contraindication for implant arthroplasty.
7. 85% strongly agreed or agreed that advanced osteoporosis is a contraindication for implant arthroplasty.
8. 70% strongly agreed or agreed that the younger or athletic patient is a contraindication for implant arthroplasty.
9. Only 50% strongly agreed or agreed that previous history of infection at the implant site is a contraindication for implant arthroplasty.
10. 65% strongly agreed or agreed that the patients' foot type has a direct relationship to the success of implant arthroplasty.
11. 75% strongly agreed or agreed that total implant arthroplasty should be reserved for those cases where joint destruction is present on the base of the proximal phalanx and also the head of the first metatarsal.
12. 65% strongly agreed or agreed that structural realignment of the first metatarsal with metatarsal osteotomy is essential in obtaining correction of the deformity.
13. 80% strongly disagreed or disagreed with the statement that implant failure may be related to the implant design primarily and not to the surgical indications or technique.
14. 75% strongly disagreed or disagreed that the indications for the hemi implant are the same indications as for the total implant.
15. 40% agreed and 25% disagreed that hemi implants should not be used when there is mild to moderate degeneration of the head of the first metatarsal. 35% were neutral on this issue.
16. 55% were neutral and 25% disagreed that more postoperative complications are noted with the total implant in comparison to the hemi implant.
17. 60% were neutral in regard to implant arthroplasty in that it is more commonly performed in the female patient in comparison to the male patient.

In addition to the responses above, each physician surveyed was given an opportunity to make additional comments or recommendations. The following questions were presented and the more common responses are included as results.

Approximately how many total implant arthroplasties have you performed in the last 5 years?

A range of 2 to 150 total implant arthroplasties were indicated on the survey. Average number reported over the last 5 years was 17.

Approximately how many hemi implant arthroplasties have you performed in the last 5 years?

A range of 2 to 200 hemi implant arthroplasties were indicated on the survey. The average number reported over the last 5 years was 38.

Which implant design and manufacturer do you prefer for the total first metatarsophalangeal joint implant?

90% of the surgeons surveyed preferred the Swanson total first metatarsophalangeal joint implant produced by Dow Corning.
Only 10% surveyed preferred the LaPorta design produced by Sutter.

Which implant design and manufacturer do you prefer for the hemi first metatarsophalangeal joint implant?

95% of the surgeons surveyed preferred the Swanson hemi first metatarsophalangeal joint implant produced by Dow Corning.
Only 5% of those surveyed preferred the LaPorta design produced by Sutter.

What percent incidence of complications have you noted following total first metatarsophalangeal joint arthroplasty?

The surgeons surveyed indicated a percent incidence of complications following total first metatarsophalangeal joint arthroplasty ranging from 1% to 20% with an average incidence of 8%.

What percent incidence of complications have you noted following hemi first metatarsophalangeal joint arthroplasty?

The surgeons surveyed indicated a percent incidence of complications following hemi first metatarsophalangeal joint arthroplasty ranging from 1% to 10% with an average incidence of 4.5%.

What factors do you feel contribute to implant arthroplasty failure?

In addition to the factors already present regarding successful implantation of the first metatarsophalangeal joint, the following is a summary list of factors contributing to implant arthroplasty failure according to the surgeons surveyed.

1. Failure to reduce soft tissue contractures
2. Poor surgical technique
3. Poor patient selection
4. Excessive compression or tension on implant
5. Too little or too aggressive bone resection
6. Poor patient compliance
7. Improper indications
8. Failure to correct osseous deformity
9. Poor bone quality
10. Failure to establish early joint motion postoperatively
11. Improper selection of implant size
12. Traumatic handling of implant
13. Use of implant to achieve angular correction
14. Lack of postoperative physical therapy
15. Basic physical limitations of silastic material as a substitute for normal bone

SUMMARY - CONCLUSION

The preliminary results of this ongoing study confirm the assumption that the implant functions mainly as a joint spacer and must not be depended on to accomplish restoration of motion and correction of the deformity. 100% of the physicians surveyed confirmed this assumption.

First metatarsophalangeal joint implant arthroplasty in most cases has been very successful in providing pain free motion.

References

1. Heubach F: Ueber hallux valgus and seine operative behandlung nach edm. *Rose Dtsch Ztschr Chir* 46:210-275, 1897.
2. Keller WL: The surgical treatment of hallux valgus surgery and bunions. *N Y Med J* 80:741-742, 1904.
3. Endler F: Zur entrichlung einer kuenstlichen athroplastik des grosszehengrundgelenkes und ihre bisherlge indikation. *Ztschr Orthop* 80:480-387, 1951.
4. Sieffert J: Nylons als knorpelersatz bei der hallux valgus opertion. *Dtsch Med J* 4:414-145, 1953.
5. Swanson A, Lumsden R, Swanson GD: Silicone implant arthroplasty of the great toe: a review of single stem and flexible hinge implants. *Clin Orthop* 142:30-43, 1979.
6. Vanore JV, O'Keefe R, Pikscher I: First metatarsophalangeal joint implant arthroplasty. In McGlamry ED (ed): *Comprehensive Textbook of Foot Surgery*, vol 1. Baltimore, Williams & Wilkins, 1987, pp 756-807.
7. Vanore J, O'Keefe R, Pikscher I: Silastic implant arthroplasty: complications and their classification. *J Am Podiatry Assoc* 74:423-433, 1984.
8. Mondul M, Jacobs PM, Caneva R, Crowhurst J, Morehead D: Implant arthroplasty of the first metatarsophalangeal joint: a 12-year retrospective study. *J Foot Surg* 24:275-279, 1985.
9. Weil LS, Pollack RA, Goller WL: Total first metatarsal joint replacement in hallux valgus and hallux rigidus. *Clinics Podiatry* 1:103-129, 1984.

Additional References

Aenson DJ: The angled great toe implant (Swanson design/Weil modification) in the surgical reconstruction of the first metatarsophalangeal joint. *Clinics Podiatry*1:89-102, 1984.

Alkin RL, Weil LS: Flexible implant arthroplasty of the great toe: an evaluation. *J Am Podiatry Assoc* 64:967-975, 1974.

Dobbs BM: Hemi-implants in foot surgery. Symposium on implants in foot surgery. *Clinics in Podiatry* 1:79-87, 1984.

Vanore J, O'Keefe R, Pikscher I: Complications of silicone implants in foot surgery. Symposium on implants in foot surgery. *Clinics in Podiatry* 1:175-196, 1984.