Clinical Efficacy of the First Metatarsophalangeal Joint Arthroplasty as a Curative Procedure for Hallux Interphalangeal Joint Wounds in Patients with Diabetes

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OBJECTIVE — To evaluate the safety and efficacy of first metatarsophalangeal joint arthroplasty compared with standard, nonsurgical management of wounds at the plantar hallux interphalangeal joint in patients with diabetes.

RESEARCH DESIGN AND METHODS — We evaluated 41 patients with ulcers classified as University of Texas Grade 1A or 2A at the plantar aspect of the first metatarsophalangeal joint using a case-control model. Case subjects were patients treated with resectional arthroplasty and control subjects received standard nonsurgical care. Both groups received standard off-loading and wound care. Outcomes included time to healing, reulceration, infection, and amputation.

RESULTS — The surgery group healed significantly faster than patients in the standard therapy group (standard 67.1 ± 17.1 versus sugery 24.2 ± 9.9 days, $P = 0.0001$), and they had fewer recurrent ulcers (standard 35.0 versus surgery 4.8%, $P = 0.02$, odds ratio 7.6, 95% CI 1.1–261.7) Both groups had similar rates of infection (standard 38.1 versus surgery 40.0%, $P = 0.9$) and amputation (standard 10.0 versus surgery 4.8%, $P = 0.5$).

CONCLUSIONS — Results suggest that resectional arthroplasty is a safe and effective procedure to treat wounds of the plantar hallux compared with nonsurgical therapy.

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Reduction of pressure in treating the diabetic foot is of paramount importance in both healing and preventing neuropathic ulcerations and their eventual sequelae. However, there may be instances in which the degree of deformity is so profound or the location of the deformity is so critical that it obviates the efficacy of both a short- and long-term extrinsic solution such as therapeutic shoes and custom molded insoles. In these instances, the focus of treatment often must be directed to the intrinsic pathology to resolve deformity and abnormal shear and pressure forces on the foot. Surgical intervention to correct structural deformity or improve limited joint mobility is often necessary when other therapy has failed.

Over the past decade, numerous descriptive studies have detailed various surgical techniques to treat diabetic foot wounds (1–15). Remarkably, only one comparative study has evaluated outcomes of nonablative foot surgery compared with nonsurgical methods of diabetic foot treatment (16). Although the conclusion of this study suggested that foot surgery seemed to be safe and effective, the study did not evaluate the effectiveness of any specific procedure, thereby limiting its ability to comment on procedure-related outcomes.

One of the most common locations of wounds on the sole of the diabetic foot is the plantar hallux (17,18). Wounds occur in this area because of a variety of factors, most significantly limitation of motion at the metatarsophalangeal joint. This limited joint mobility leads to increased plantar pressure on the hallux, which, when combined with repetitive stress (activity during walking), results in neuropathic foot ulceration (2,19). By extension, therefore, one of the most commonly used procedures by surgeons interested in this area is arthroplasty of the first metatarsophalangeal joint (20,21). No reports evaluating safety or outcomes of this procedure exist in the medical literature. Therefore, the purpose of this case-control study was to evaluate the complications and outcomes of first metatarsophalangeal joint arthroplasty compared with standard, nonsurgical management of wounds at the plantar hallux interphalangeal joint.

RESEARCH DESIGN AND METHODS

— This project, designed as a case-control model, was conducted at

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A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

Table 1—*Population descriptive statistics*

	First metatarsophalangeal arthroplasty	Control	Total
n	21	20	41
Age	70.5 ± 7.6	69.8 ± 10.3	70.2 ± 8.9
Sex (% male)	90.5	100	95.1
GHb (%)	7.9 ± 1.4	8.4 ± 1.2	8.2 ± 1.4
Duration of diabetes (years)	14.1 ± 3.4	13.7 ± 3.1	13.9 ± 3.2
Duration of wound (weeks)	15.6 ± 6.4	15.5 ± 5.9	15.5 ± 6.1

Data are *n* or means ± SD.

a large, referral-based diabetic foot clinic located in a teaching institution. We abstracted medical records from 42 patients with diabetes, aged 70.2 ± 8.9 years, who met the following criteria: *1*) diagnosis of diabetes by the primary care physician, *2*) presence of a single neuropathic wound of the plantar hallux interphalangeal joint, *3*) ability to ambulate freely without assistance of a wheelchair, and *4*) at least 6 months of reliable follow-up information. All wounds were classified as University of Texas Grade 1A or 2A (wounds without infection/ischemia not involving bone or joint) (22). Data were abstracted over a 2-year period for any first metatarsophalangeal joint arthroplasty procedure performed during that period of time, yielding 21 procedures. These were compared to 20 age- and sex-matched control subjects receiving standard nonsurgical care for hallux interphalangeal joint wounds, thus yielding a 1-to-1 case-to-control ratio.

Patients were excluded if they had a diagnosis of clinically significant vascular disease. Vascular status was evaluated by palpation of pedal pulses. Diagnosis of ischemia was standardized in the facility where data were abstracted and was made by the absence of more than one foot pulse or a nonaudible signal on Doppler ultrasonography of the dorsalis pedis or posterior tibial pulses on the affected extremity. This method of evaluation, although arguably not as sensitive as other noninvasive methods such as transcutaneous oximetry, segmental extremity pressure studies, or laser Doppler flowmetry, has the benefit of having been performed systematically on all patients in this study (23–26).

Patients were excluded from analysis if they had a clinical diagnosis of acute soft-tissue or bone infection. Soft-tissue or bone infection was a clinical diagnosis made by the treating physician at the time of assessment. As per standard protocol, the diagnosis of infection was consistent with the current criteria described by the International Working Group on the Diabetic Foot (27), which includes presence of purulence, advancing cellulitis, or two or more other local signs of inflammation.

Patients in both the surgery and control groups were treated in a standardized fashion per protocol followed in the high-risk diabetic foot center where treatment was rendered. All procedures performed were categorized as diabetic foot surgery class 3 (curative) using the classification described by Armstrong and Frykberg (28). The arthroplasty performed on all subjects within the surgery group was a Keller-type first metatarsophalangeal joint arthroplasty. This procedure, performed through a dorsal linear incision over the digit and metatarsophalangeal joint, involves resection of the base of the proximal phalanx, thereby increasing range of motion at the articulation of the hallux to the first metatarsal (29,30). All procedures were performed using local anesthesia and monitored sedation. These procedures were performed by one of two attending surgeons (D.G.A. and B.P.N.). Postoperative care for all patients was identical, with the first dressing change performed 2 days after surgery and weekly evaluation thereafter. The plantar hallux wound was dressed with a moisture-retentive gauze and was not disturbed between weekly postoperative visits. On postoperative visit 3 (at 2 weeks), sutures were removed. Patients were then switched to a daily dressing change regimen until the wound healed. Patients were off-loaded in a standard fashion using an Active Offloading Walker or DH sandal (Royce Medical, Camarillo, CA). These devices were converted into "instant total contact casts" at the discretion of the attending clinician using the technique described by Armstrong and colleagues (31,32). The instant total contact cast involves wrapping a removable cast walker with cohesive bandage or plaster of Paris in an effort to ensure adherence to pressure off-loading. Patients in the control group were treated with moisture-retentive dressings and were offloaded in a similar manner to the patients in the surgical group.

Care after healing was identical in both groups, according to a standardized protocol in place at the treating clinic. All subjects whose wounds had healed were assessed for appropriate footwear by the podiatrist and prosthetics/pedorthics team, as required. This footwear consisted of either comfort shoes or prescriptive-depth inlay shoes with sufficient

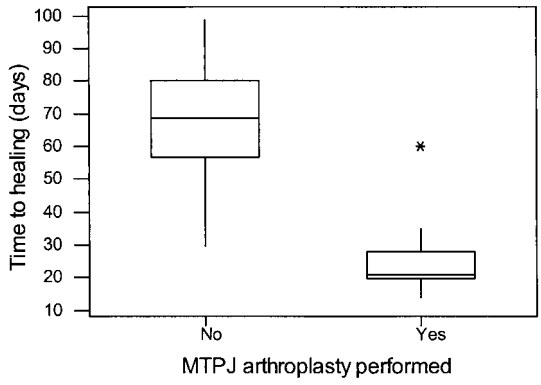

Figure 1—*Time to healing with metatarsophalangeal joint arthroplasty. Difference in time to healing is significant at* P = *0.0001. *Outlier (60 days). The bisecting line refers to the median, and the limits of the box connote the first and third quartiles. Whiskers extend to the upper and lower limit values.*

space in the toebox to accommodate a pressure-reducing insole. Patients were followed every 2 months after healing for foot examination and footwear checks.

We evaluated several outcome variables at the aforementioned 6-month period in this case-control model, including time to healing, proportion of infections, proportion of reulceration, and proportion of amputation at 6 months. Healing was determined as complete epithelialization of the wound. To evaluate the differences in continuous variables between the surgery and control groups, we used a Kruskal-Wallis test for nonparametric samples. To evaluate dichotomous variables, we used a χ^2 test (33). All data were reported as mean ± SD unless otherwise stated.

RESULTS — Descriptive characteristics for this population are outlined in Table 1. There was no significant difference in age ($P = 0.8$), duration of diabetes ($P = 0.8$), wound duration before treatment ($P = 0.9$), wound size ($P = 0.9$), or GHb ($P = 0.2$).

Patients who underwent metatarsophalangeal joint arthroplasty healed significantly faster than patients in the standard therapy group (67.1 ± 17.1 vs. 24.2 ± 9.9 days, $P = 0.0001$). These data are summarized in Fig. 1. Additionally, ulceration recurred in significantly fewer patients during the 6-month follow-up period (4.8 vs. 35.0%, $P = 0.02$, odds ratio 7.6, 95% CI 1.1–261.7). In all subjects in the control group who experienced reulceration, the recurrence developed at the site of previous injury (hallux interphalangeal joint). In one subject in the surgery group, reulceration developed at the plantar heel. There was no significant difference in the proportion of patients with infection (38.1 vs. 40.0%, $P = 0.9$) or those undergoing amputation during the follow-up period (4.8 vs. 10.0%, $P = 0.5$).

CONCLUSIONS — The results of this study suggest that metatarsophalangeal joint arthroplasty is a safe and effective procedure in the treatment of noninfected, nonischemic wounds of the plantar hallux when compared with nonsurgical therapy. Although this type of procedure seems to be performed commonly in patients with diabetic foot ulcers of the hallux, this is the first report in the medical literature to make this comparison.

Most of the work in the area of diabetic foot surgery has consisted of descriptive, case series of isolated procedures. The one randomized controlled trial in this area, conducted by Piaggesi et al. (16), amalgamated various types of procedures into a 21-patient surgical cohort (some patients with multiple wounds). Although this important article strongly suggested that the time to wound healing was more rapid than nonsurgical therapy, it was not possible to draw any conclusions about procedure-related outcomes. Therefore, this was the intention of the present study. A procedure was selected that addressed the most common location for a diabetic foot ulcer (the plantar hallux).

One of the significant limitations of this study, particularly when compared with the Piaggesi project, is that it is case-control design rather than prospective and randomized. Most significantly, this exposes the data to potential selection bias. Although this is a valid concern, because of the rather rigid protocols followed in the treating clinic, it was quite difficult to retrospectively find differences between the two groups in terms of descriptive characteristics. The most obvious question would then be, "if these patients are so similar, then why were some patients operated on and others not?" The clearest answer to this lies in the difference in philosophy between the two attending surgeons who managed the clinic. During the period of review, one favored a primarily surgical approach to this specific type of lesion, while the other favored a primarily nonsurgical technique. Whatever the reason for surgical versus nonsurgical decision making in these noninfected, nonischemic lesions, it seems that the data compare quite favorably to the aforementioned Piaggesi study in terms of healing time, recurrence (both studies used 6-month time periods to assess this), and complications.

The first metatarsophalangeal joint arthroplasty procedure performed in this study was initially described by Keller in 1904 and subsequently in 1912 for correction of painful bunion deformity (34,35). This procedure gained popularity throughout the early and middle 20th century before the widespread use of metatarsal osteotomies to correct that type of deformity. After this, the procedure continued to remain popular, but more so as a treatment for arthritis of the first metatarsophalangeal joint, particularly in patients who did not require heavy demand on the joint (29,36). It has subsequently become a commonly performed procedure in patients with diabetes-related neuropathic wounds under the hallux secondary to limited mobility of the metatarsophalangeal joint (20,21,30). However, until the present study, no data have been reported about its potential utility or safety.

There was a very high prevalence of postoperative infection in this group (40%). This is much higher than descriptive reports of prevalence of infection in nondiabetic elective foot surgery, which range in the area of 1–3% (37–40). This very high rate compares favorably, however, with the proportion of patients in the control group requiring treatment for infection during the period of therapy (38%). Furthermore, Lavery et al. (41) reported an infection-to-ulcer ratio of 56% during the life cycle of lower extremity wounds in patients with diabetes. Additionally, it seems that the high rate of infection reported in these patients did not correlate with an extended time to wound healing (median 21 days) in the group receiving surgical intervention.

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