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Dorsiflexory Phalangeal Osteotomy for Grade II Hallux Rigidus: Patient-Focused Outcomes at Eleven-Year Follow-Up

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ABSTRACT

Dorsiflexory phalangeal osteotomy has been shown to be an effective treatment for mild to moderate hallux rigidus in short- to medium-term follow-up studies. It is speculated that the procedure alters the mechanical function of the joint and reduces the demand for hallux dorsiflexion by elevating the proximal phalanx into a more dorsiflexed position. However, it has been demonstrated that the first metatarsophalangeal (MTP) joint space and joint range of motion are reduced by the procedure, calling into question the long-term effectiveness of the operation. This study reviewed 27 dorsiflexory phalangeal osteotomy cases at an average of 11 years postoperatively. Twenty-one (77%) patients reported that they were completely satisfied with the results of their surgery; 4 (15%) patients reported that they were satisfied with reservations; and 2 (7%) patients reported that they were dissatisfied. The patients who were satisfied with reservations complained of interphalangeal (IP) joint pain or stiffness. One patient developed second MTP joint metatarsalgia after surgery, and in 1 patient first MTP joint pain returned at 24 months after surgery. One dissatisfied patient complained of second MTP joint metatarsalgia, and a second patient required revision excisional arthroplasty for continued joint pain. Ten patients (38%) reported stiffness of the first MTP joint, but only 2 patients reported any restriction of activity. Footwear restrictions were reported by 15 (58%) patients preoperatively and by 9 (35%) patients at final follow-up. Dorsiflexory phalangeal osteotomy maybe a reliable long-term treatment for grade II or moderate hallux rigidus and is a safe and effective alternative to first MTP joint fusion in joints where movement is still present and joint cartilage is viable.

Hallux rigidus is a degenerative arthritic condition of the first metatarsophalangeal (MTP) joint. It presents in mild, moderate, and severe forms and is a common cause of foot pain. The condition is most commonly reported in females over 40 years of age (1), and symptoms will often be exacerbated by activity and certain forms of footwear (2,3).

The usual options for the surgical treatment of hallux rigidus include arthrodesis, excisional arthroplasty, silastic joint replacement, metallic joint and hemi joint implant, hydrogel joint resurfacing, metatarsal osteotomy, and phalangeal osteotomy. Arthrodesis of the first MTP joint is well documented as the "gold standard" treatment for this condition, since it is an effective means of resolving pain and reducing footwear irritation of the dorsal osteophytes (4). It is not, however, without risk, with complications of nonunion, transfer metatarsalgia, and interphalangeal joint pain being reported (5–8). Depending on the technique used, immobilization is often required for some weeks postoperatively, with consequent delay of return to normal activities. An important issue is that many patients with hallux rigidus present with a complaint of joint stiffness, restricting their activities or footwear choices. A fusion procedure will obviously restrict movement further and is perhaps less than ideal in the early stages of this condition where there is still viable joint cartilage and minimal joint stiffness.

Excisional arthroplasty of the first MTP joint was first described in 1904 for the treatment of hallux rigidus and hallux valgus. Although still frequently used for selected cases of hallux rigidus, it produces shortening and weakness of the hallux, which can leave the patient at risk of transfer metatarsalgia. It is, therefore, avoided in younger, more active patients, although it will restore movement to the hallux and improve footwear fitting (9,10). Length of the great toe may be preserved with a silastic joint implant, but lifespan of the implant is limited and will not prevent transfer metatarsalgia, since detachment of the flexor hallucis brevis tendon is necessary in many forms of joint

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arthroplasty. This may lead to weakness of the hallux and transfer of load to the second MTP joint.

Metallic double-stemmed and hemi implants have been reported in small numbers as undergoing microscopic metallic wear with local tissue response. Also, these types of implants have been associated with a high incidence of bony overgrowth (28%) and osteolytic changes (19%), possibly leading to loosening and subsidence of the implant (11–13).

Hydrogel joint resurfacing of the first metatarsal head is a synthetic cartilage made from polyvinyl alcohol. It has been found in a recent level 1 multicenter study to reduce pain by 93% and produce patient outcomes similar to first MTP joint arthrodesis, while improving joint movement across a range of mild to severe cases of hallux rigidus. However, long-term survival rates are yet to be determined (14).

Metatarsal osteotomies preserve the first MTP joint and are indicated for mild to moderate hallux rigidus deformities. These osteotomies are designed to decompress the joint by shortening the metatarsal or rotating the plantar cartilage of the first metatarsal head more dorsally to articulate with the hallux. Shortening the first metatarsal does place the patient at grave risk of transfer metatarsalgia, with 1 study recording a 30% incidence of metatarsalgia and no significant increases in the range of joint motion (15).

In 1958, Kessel and Bonney (16) of St. Mary's Hospital, London, reported the outcomes of 9 adolescent patients who underwent an extension or dorsiflexory phalangeal osteotomy, with a follow-up period of 5 to 54 months (Fig. 1).

In all cases, hallux dorsiflexion was increased, and in all but 1 patient, symptoms were relieved and painless function restored. Roukis (17) conducted a systematic review of 11 studies of cheilectomy and phalangeal dorsiflexory osteotomy, with a mean follow-up period of 12 months. In 6 studies, the degree of hallux rigidus was recorded and included grade I to grade III, according to the Hattrup-Johnson scale. In 374 procedures, pain was relieved in 89%, and 77% of patients were satisfied or very satisfied with their outcomes. Just under 5% of patients required revision surgery. Despite the findings of general improvement in subjective and objective data and a low incidence of revision surgery, Roukis (17) thought that further prospective research was required, with a focus on outcomes in specific grades of hallux rigidus.

Kilmartin (15) reported a prospective study of dorsiflexory phalangeal osteotomy and cheilectomy on 49 feet presenting with grade I or II hallux rigidus, with a mean follow-up of 29 months, and found that 89% of patients were either completely satisfied or satisfied with some reservations. Revision excisional arthroplasty was required in 2 (4%) patients. It was noted, however, that phalangeal osteotomy led to loss of joint space and reduced joint range of movement, which was a significant concern for the long-term effectiveness of the procedure (Fig. 2).

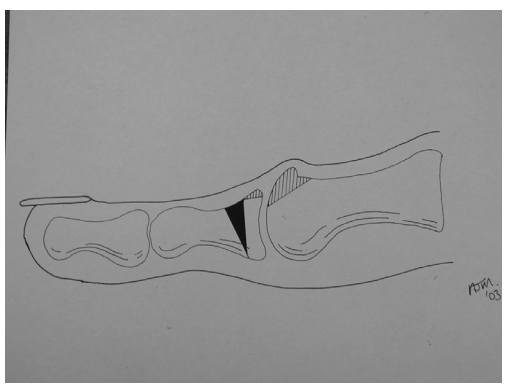

Fig. 1. Line drawing of dorsiflexory phalangeal osteotomy (10).

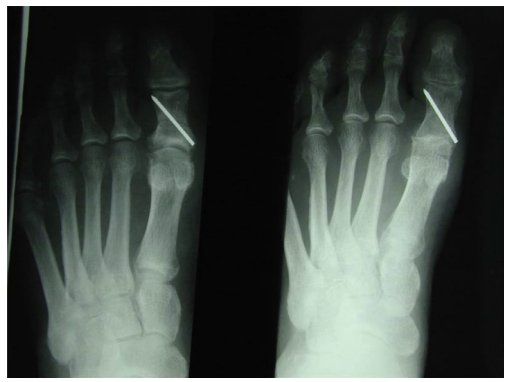

Fig. 2. Radiographs showing loss of first metatarsophalangeal joint space after dorsiflexory phalangeal osteotomy. The image on the left was taken at 1 week postoperatively; the image on the right was taken at 2 years postoperatively.

Although it was apparent that the osteotomy could change the mechanics of first MTP joint motion to provide pain-free joint movement, it was uncertain how long this effect would last. The question is whether the condition of the first MTP joint will just continue to deteriorate, eventually requiring revision surgery. This study reviewed the long-term outcomes of the dorsiflexory phalangeal osteotomy, to establish its role in the management of grade II hallux rigidus where there is still some movement of the joint and viable joint cartilage (18).

Patients and Methods

Between May 1999 and August 2005, dorsiflexory phalangeal osteotomy was performed consecutively on 32 patients (33 feet), for the treatment of grade II hallux rigidus according to the Hattrup-Johnson scale (18) (Table 1, Fig. 3). All patients were referred to a hospital-based podiatric surgery unit by their primary care physician and underwent surgery when conservative measures, including orthoses and cortisone injection therapy, proved ineffective. The indications for surgery were joint pain, associated joint stiffness, and footwear-fitting difficulties caused by dorsomedial exostosis. In 2015, all 32 patients were contacted by the primary author (A.C.) and invited to once more attend the unit for follow-up and review (Fig. 4). Five patients were lost to follow-up, and 1 patient declined to participate in the study.

In all cases, the procedure was performed by the second author (T.K.), and the review was performed by the primary author (A.C.).

Operative Technique

In all cases, the procedure was performed as a day-case operation under ankle block local anesthesia. An ankle tourniquet was applied, and a medial skin incision was extended from the first metatarsal shaft to the hallux interphalangeal joint. An ellipse of joint capsule was excised, and dorsal, lateral, and medial osteophytic thickening of the metatarsal head was resected using a power saw. A 4-mm dorsal wedge of bone was then resected from the proximal part of the phalanx of the hallux, making sure to keep a plantar cortical hinge intact (Fig. 5). The wedge osteotomy was then closed by feathering the hinge and fixed with a 1.5-mm threaded K-wire. The capsule was repaired using 2-0 Vicryl, and the skin closed with subcuticular Monocryl sutures.

The foot was bandaged and placed in a wooden-soled surgical shoe for 2 weeks, and patients were encouraged to heel walk. All dressings were removed 2 weeks postoperatively, and the patients were asked to return to lace-up running shoes and then gradually return to normal activities. Patients were advised to actively propulse through the hallux on gait. Additionally, patients were advised to perform toe flexion exercises against the resistance of green TheraBand at a rate of 30 repetitions twice a day (Fig. 6). Patients were again reviewed at 6 months postoperatively and then discharged.

Twenty-six patients (27 feet; 14 right feet and 13 left feet) attended for final review (start, June 2015; end, July 2015) with the primary author (A.C.). The mean follow-up period was 11 years and 3 months (range 116 to 192 months). At the time of surgery, the mean age of the patients was 57 years (range 45 to 74 years), and at follow-up the mean age was 69 years (range 56 to 83 years), with 19 female feet and 8 male feet. One male patient (right foot) was found to have undergone revision Keller excisional arthroplasty surgery due to failure of the dorsiflexory phalangeal osteotomy to reduce first MTP joint pain. This case was recorded as a dissatisfied outcome, although the patient was unable

Table 1
Hattrup-Johnson joint classification of hallux rigidus (adapted from 18)

Stage of condition	Radiographic appearance
Grade I	Degenerative changes with mild dorsal exostosis and good joint preservation.
Grade II	Degenerative arthritis with definite joint space narrowing accompanying the dorsal osteophyte and subchondral sclerosis.
Grade III	Marked osteoarthritis with loss of the joint space and possible subchondral cysts

to complete the patient-reported outcome measures. He could not differentiate the outcome of his revision surgery from the original dorsiflexory phalangeal osteotomy procedure because of the distance of time involved. Also, objective assessments were not performed on this case.

At final review, pain and activity levels were assessed using standardized questions for all patients. Patient satisfaction with their surgical outcome was recorded qualitatively as completely satisfied, satisfied with reservations, or dissatisfied. Satisfied with reservations usually indicated ongoing concerns with continued (though reduced) first MTP joint pain or new related conditions. Cosmetic concerns, footwear fitting difficulties, and postoperative complications were also recorded if present. Range of motion of the first MTP joint was measured nonweight-bearing using a digital goniometer (Figs. 7,8).

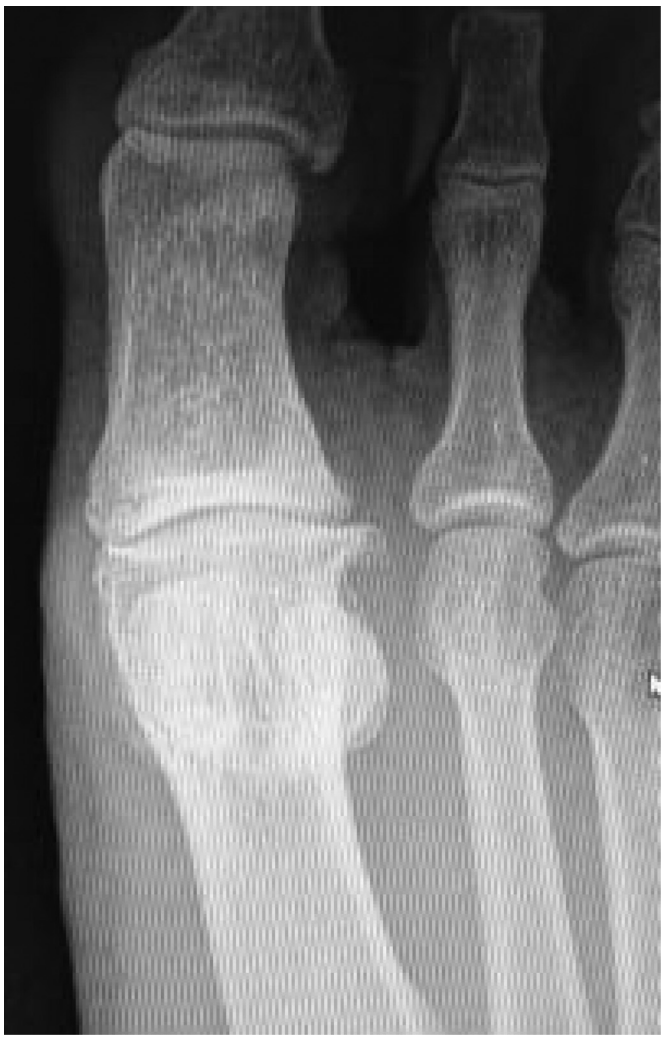

Fig. 3. Radiograph of first metatarsophalangeal joint grade II on the Hattrup-Johnson scale.

Active plantarflexion of the hallux was evaluated by asking the patient to pick up a paper towel off the floor while maintaining the foot in a plantigrade position (Fig. 9).

All patients were asked to complete the Manchester-Oxford Foot Questionnaire (MOxFQ) (19) and the American Orthopedic Foot & Ankle Society (AOFAS) clinical rating scale (20,21). The MOxFQ is a patient-reported outcome measure that records a score of 0 to 100. The lower the score, the greater the improvement of the original pathology. Three outcomes are measured by the MOxFQ: pain, walking/standing ability, and social interaction.

Statistical calculations were all conducted by the primary author (A.C.), except for the standard deviation calculations, which were conducted by the second author (T.K.).

Results

A total of 27 patients attended for final review. Twenty-one (77%) patients reported that they were completely satisfied with the results of their surgery; 4 (15%) patients reported that they were satisfied with reservations; and 2 (7%) patients reported that they were dissatisfied, with inclusion of the revision case. All patients said that they would be happy to undergo surgery under similar circumstances again if required (i.e., under local anesthesia on a day-case basis).

The patients who were satisfied with reservations complained of interphalangeal joint stiffness in 1 case and interphalangeal joint pain in 1 case. One patient developed second MTP joint metatarsalgia postoperatively, and in 1 patient first MTP joint pain returned at 24 months postoperatively, though markedly reduced. One dissatisfied patient presented for review with a markedly floating hallux and second MTP joint metatarsalgia; the other dissatisfied patient underwent required revision Keller excisional arthroplasty because of continued first MTP joint pain. With exclusion of the revision case from the rest of the data, due to the patient being unable to distinguish between the outcome of his original surgery and the revision surgery, 25 patients (96%) reported pain reduction, while 21 (77%) patients reported complete pain relief from the joint.

AOFAS scores were recorded preoperatively in 15 cases, with a mean score of 47 $\pm$ 5.4. This had risen to a mean score of 81 $\pm$ 11.4 in the 26 cases reviewed at final follow-up. This was a highly statistically significant difference ($p < .001$, unpaired t test with Welch correction). The MOxFQ patient-reported outcome measure recorded 3 outcomes: pain, walking/standing ability, and social interaction. After dorsiflexory wedge osteotomy, the mean score was 18 $\pm$ 22.9 out of a possible score of 100 for pain, 14/100 $\pm$ 25.7 for walking/standing, and 9/100 $\pm$ 15.2 for social interaction. The lower the MOxFQ score, the better the outcome. Table 2 presents confidence intervals for all patient-reported outcomes and objective measurements.

The mean passive range of motion measured off weight-bearing with a digital goniometer was 18° $\pm$ 16° dorsiflexion and 10° $\pm$ 9° plantar flexion. Active plantar flexion, defined by a patient's ability to pick up a paper towel with their hallux while keeping the foot in a plantigrade position, was present in 21 (81%) cases, whereas 5 (19%) patients could not pick up the paper towel at all.

Ten (38%) patients reported stiffness of the first MTP joint, but only 2 (7%) patients reported any restriction of activity. Footwear restrictions were reported by 15 (58%) patients preoperatively and by 9 (35%) patients at final follow-up. All were female.

No cases of postoperative infection, cosmetic concerns, fixation irritation, nonunion, or venous thromboembolism were reported.

Discussion

Dorsiflexory phalangeal osteotomy, as first described by Kessel and Bonney in 1958 (16), is an effective procedure for remodeling an arthritic first MTP joint, restoring pain-free movement to the joint, and alleviating the pain associated with footwear irritation of dorsal and medial osteophytes of the metatarsal head. Although previous case series have determined high patient satisfaction, effective pain relief,

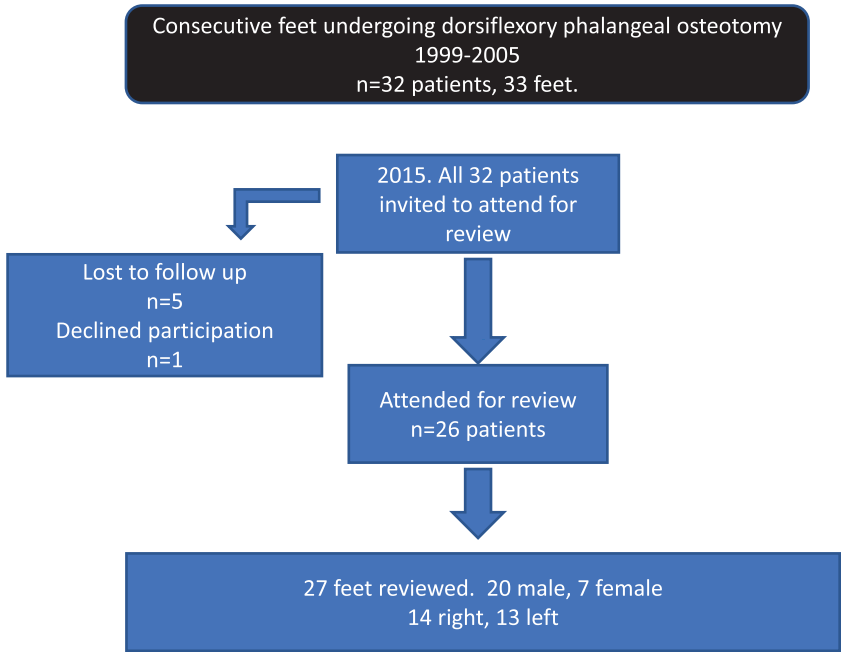

Fig. 4. Recruitment of the study population.

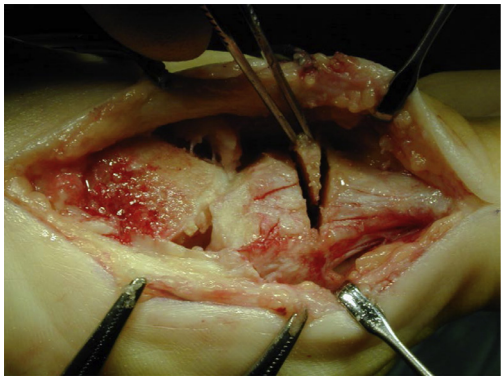

Fig. 5. Intraoperative picture of dorsal wedge osteotomy.

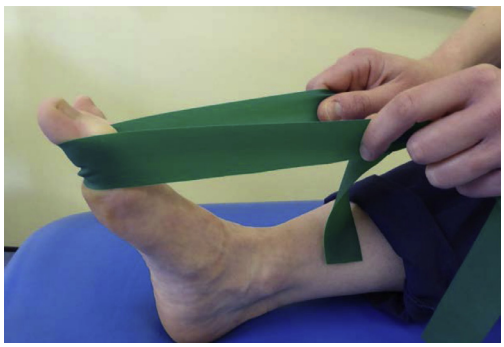

Fig. 6. Powerband flexion exercises against resistance.

and good functional outcomes (14,15,22), it remains uncertain how long such a positive effect will last. The procedure was doing nothing to prevent continued attrition of an already damaged first MTP joint surface. Our series found that just 1 case out of 27 required revision excision arthroplasty surgery in the mean 11-year follow-up period after dorsiflexory phalangeal osteotomy. This 1 patient was happy with their ultimate outcome after revision surgery but was obviously considered a poor outcome after the dorsiflexory phalangeal osteotomy.

Significantly, while 4 (15%) patients in our series were only partially satisfied with the outcome of their phalangeal osteotomy, dissatisfaction was due to the development of secondary problems like metatarsalgia and hallux interphalangeal joint pain rather than recurrent first MTP joint pain.

Clearly, dorsiflexory phalangeal osteotomy does not restore joint cartilage, so could the effect on first MTP joint movement explain how the osteotomy can relieve joint pain? In the original description of the procedure, Kessel and Bonney (16) described how dorsiflexion increased from 5° to 44° in 10 cases, but plantarflexion range was reduced from 50° preoperatively to 5° postoperatively. Kilmartin (15) measured first MTP joint dorsiflexion using an O'Brien goniometer, which recorded dynamic dorsiflexion of the hallux in the walking patient, and found that, 2 years after dorsiflexory phalangeal osteotomy, first MTP joint dorsiflexion was actually reduced by a mean average of 1°. Lateral weight-bearing radiographs, however, indicated that after dorsiflexory phalangeal osteotomy, the proximal phalanx of the hallux is hyperextended by a mean of 8° (Fig. 10). Kilmartin suggested that this effectively reduced the demand on the first MTP joint because the hallux is placed in a dorsiflexed position, and thus less dorsiflexion is required later in the propulsive phase of gait (15). The elevated position of the proximal phalanx would also reduce plantarflexion range of first MTP joint motion, as previously noted by Kessel and Bonney (16).

The altered position of the proximal phalanx may also explain an important complication of phalangeal osteotomy: interphalangeal joint pain. This is a complication that can also be seen after poorly aligned first MTP joint fusion, when the proximal phalanx is fixed in an excessively dorsiflexed position. We suspect that the hyperextended position of the hallux proximal phalanx alters the loading of the interphalangeal joint surface, leading to pain within the joint. We subsequently found that this complication can be effectively treated by excision arthroplasty of the interphalangeal joint if symptoms warrant it.

Table 2
Patient-reported outcomes and first metatarsophalangeal joint range of motion confidence intervals (CIs)

	Mean	SD	95% CI lower	95% CI Upper	Median
Postoperative dorsiflexion (n = 26)	18°	16	11.7	25.3	10°
Postoperative plantarflexion (n = 26)	9°	9.07	5.7	13.4	5°
AOFAS score preoperative (n = 15)	48.5	5.4	44	52	49
AOFAS score postoperative (n = 26)	80.7	11.4	75	86	83
MOxFQ pain score postoperative (n = 26)	18.2	22.9	8.7	27.6	15
MOxFQ walking/standing score postoperative (n = 26)	13.7	25.7	3	24.3	0
MOxFQ social interaction score postoperative (n = 26)	9.1	15.2	2.8	15.3	0

MOxFQ, Manchester-Oxford Foot Questionnaire; SD, standard deviation

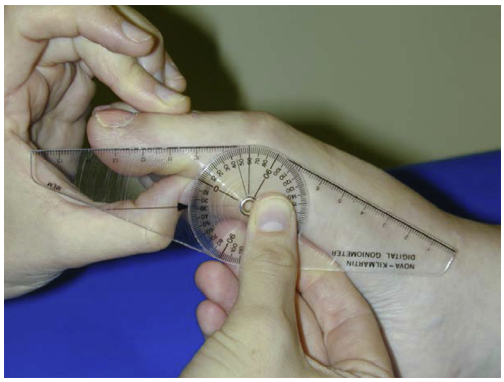

Fig. 7. Measuring the range of plantarflexion at the first metatarsophalangeal joint using a Kilmartin goniometer (10).

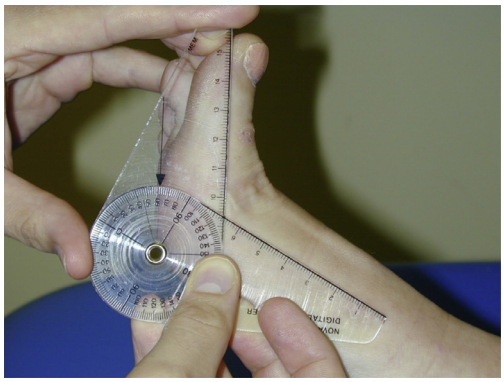

Fig. 8. Measuring the range of dorsiflexion at the first metatarsophalangeal joint using a Kilmartin goniometer (10).

The range of passive first MTP joint motion measured at final follow-up visit in this case series was poor, with a mean dorsiflexion of just 18° and a mean plantarflexion of 10°. This indicated that although the joint was usually functioning without pain, it was not functioning normally, and the degenerative changes associated with joint stiffness had not been reversed. Limitation of first MTP joint dorsiflexion after phalangeal osteotomy has important implications for those patients most likely to undergo this procedure (i.e., those with mild to moderate radiographic changes but significant joint pain, which can be particularly problematic for women wanting to wear high-heeled shoes). Fifteen of the 19 (79%) female patients in this series reported difficulties in wearing high heels prior to surgery. At final follow-up visit, 9 (47%) of those female patients continued to have difficulties wearing high-heeled shoes specifically because of first MTP joint pain, when the hallux was forced into

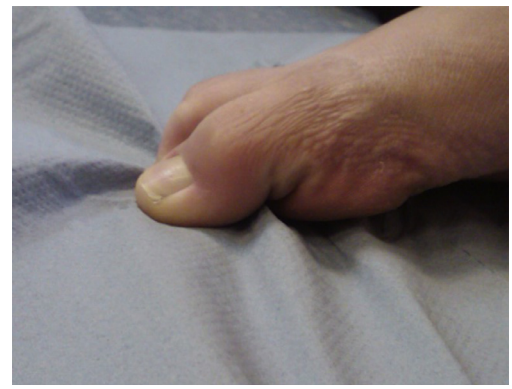

Fig. 9. Pick-up paper test (10).

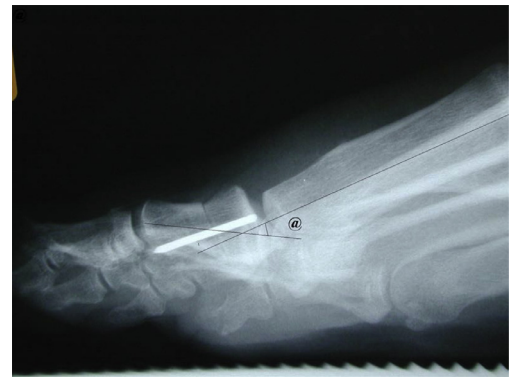

Fig. 10. Lateral radiograph showing hyperextended hallux.

a higher dorsiflexion angle. As part of the informed consent process, we now highlight this risk of continued footwear restrictions for female patients.

First MTP joint fusion has long been considered the "gold standard" procedure for hallux rigidus, not least because its success is widely reported in the literature. However, few studies have ever asked patients if they would prefer a rigid fused great toe joint to a flexible joint. When this has been done, many patients will elect to undergo surgery that will preserve first MTP motion (14). Since one of the symptoms associated with hallux rigidus is joint stiffness, it can be difficult to persuade patients to undergo an operation that will make the joint even stiffer. This can be particularly problematic for both clinicians and patients when the degenerative joint changes are mild or moderate only, and fusion of the joint may restrict certain physical activities or footwear choices. First MTP joint fusion is also not without risk of nonunion, malunion, transfer metatarsalgia, and the development of interphalangeal joint osteoarthritis (5–8). Dorsiflexory phalangeal osteotomy avoids the need for postoperative immobilization and has no reported risk of nonunion. Although potentially a cause of pain in the interphalangeal joint, phalangeal osteotomy did not, in this series of patients, cause clinically apparent interphalangeal joint degeneration. Radiographs were not, however, taken at final review, so it is possible that degenerative changes could have been identified on radiographic examination. This is an obvious weakness of the study, but unfortunately ethical approval for radiographic review of the case series' patients was not forthcoming.

Metatarsal osteotomy has also been considered an option in early-stage hallux rigidus, grade II on the Hattrup-Johnson scale. Cho et al (23) reviewed 42 patients who underwent dorsiflexion wedge

osteotomy of the first metatarsal, which shortened the first metatarsal and rotated the viable plantar cartilage of the metatarsal head. They found that fusion of the first MTP joint was subsequently required in 9.5% of patients to resolve continued joint pain, and 5% of the study group developed transfer metatarsalgia postoperatively. However, in another recent study of 40 patients with moderate hallux rigidus who underwent L-shaped distal metatarsal osteotomy and who were reviewed at 35 months postoperatively, Ceccarini et al (24) encountered only transient transfer metatarsalgia and recorded no requirement for further treatment despite significant shortening of the first metatarsal.

Though limited in number, previous outcome studies of first metatarsal osteotomy for hallux rigidus have reported a significant incidence of complications, particularly transfer metatarsalgia (15). Shortening of the first metatarsal to decompress the joint even when the first metatarsal is considered long relative to the second metatarsal leaves the patient at grave risk of transfer of load to the second MTP joint (15). The validity of shortening the first metatarsal to restore the metatarsal parabola to what is notionally considered the "normal parabola" is therefore open to question. Dorsiflexory phalangeal osteotomy is also associated with metatarsalgia, although the incidence is much less. We suspect that transfer metatarsalgia occurs after dorsiflexory phalangeal osteotomy, since the reduced plantarflexion range of motion of the hallux in turn reduces propulsive power of the hallux. This may then predispose to transfer metatarsalgia as the person pushes off the lateral forefoot rather than the hallux.

Dorsiflexory phalangeal osteotomy is a safe and effective alternative to the present gold standard treatment for hallux rigidus—joint fusion. Based on this study of grade II hallux rigidus, phalangeal osteotomy is an effective long-term intervention in appropriately selected cases. Although revision surgery is rarely required, it is straightforward to convert to either excision arthroplasty or first MTP joint fusion. In the same way that a range of procedures is considered necessary for treating hallux valgus, we think that a variety of approaches is also necessary for the management of hallux rigidus. Dorsiflexory phalangeal osteotomy is an important option for patients with early and moderate hallux rigidus who, for reasons of lifestyle or footwear choice, want to preserve first MTP joint motion.

A significant weakness of this study is the loss of 6 cases out of 33 (18%). Unfortunately, this is probably unavoidable in a long-term review of elderly patients, but it does diminish the reliability of any conclusions, as the patients lost could have suffered poor outcomes that were not recorded. The validity of the MOxFQ patient-reported outcomes were diminished by the absence of preoperative MOxFQ scores; however, the final scores at the follow-up visit were included to allow comparison with other studies where the MOxFQ was applied (25). We think that the consistency of the outcomes across the case series, after such a long period of follow-up, allows the findings to be presented with reasonable confidence.

In conclusion, in this case series, at a mean follow-up of 11 years, dorsiflexory phalangeal osteotomy continued to relieve joint pain in 96% of cases, with complete pain relief in 77%. Joint stiffness and related footwear restrictions continued to be an issue in 35% of female patients. Phalangeal osteotomy may be a reliable long-term treatment for grade II or moderate hallux rigidus. It is certainly a safe and effective alternative to first MTP joint fusion in selected patients who want to preserve their first MTP joint movement.

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