



Arthrodesis of the first metatarsophalangeal joint using convex and concave drills A report on 50 cases

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The authors report their results after arthrodesis of the first metatarsophalangeal joint (MP) performed in 50 cases including 18 rheumatoid feet, 18 major hallux valgus deformities and 14 recurrent deformities. Preparation of the bone ends for arthrodesis was achieved using convex and concave drills and fixation was done with an axial screw. The patients were evaluated after an average of 12 months, using Kitaoka's score. Eighty per cent were very satisfied, 16% were satisfied and 4% were dissatisfied. Ninety six percent reported no pain over the MP joint of the hallux, and none complained of metatarsalgia. Return to activities was normal in 80% of cases. Radiographs showed non-union in six cases ; they did not show interphalangeal osteoarthritis in any instance.

INTRODUCTION

Fusion of the metatarsophalangeal joint of the hallux remains a method of choice in the treatment of severe forefoot deformities secondary to rheumatoid arthritis, recurrence of hallux valgus, iatrogenic hallux varus and hallux rigidus. It does not impair function insofar as the talocrural and interphalangeal joints are intact.

Arthrodesis of the metatarsophalangeal of the hallux was first described in the nineteenth century, and was found to provide satisfactory and stable results in cases of severe hallux valgus deformities. A number of techniques have been reported. The

technique using a set of concentric drills, one convex for the metatarsal head and the other concave for the base of the phalanx, allows optimal positioning of the great toe.

The purpose of this study was to assess the functional results of this operation performed with a set of concentric drills : a convex drill to prepare the metatarsal head, and a concave drill to prepare the base of the phalanx.

MATERIAL AND METHODS

Patients

Between 1999 and 2001, 50 feet (26 right, 24 left) including 8 bilateral cases were operated by the same

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senior surgeon in the Orthopaedic department of the University Hospital in Amiens. The patients were predominantly female : 36 versus 14 male. The mean age at operation was 64.6 years (range : 47 to 88).

Indications for arthrodesis were rheumatoid arthritis in 18 cases (36%), hallux valgus with major deformity and/or degenerative metatarsophalangeal osteoarthritis in 18 cases (36%) and recurrent hallux valgus deformity in 14 cases (28%).

All patients complained of pain in the forefoot, involving the hallux, together with the 2nd metatarsal in 28 cases, the 3rd in 26 cases, the 4th in 20 cases and the 5th metatarsal in 14 cases. A bursa over the prominent metatarsal head was present in all cases, as was plantar hyperkeratosis.

On podoscopic examination, we noted a normal plantar footprint in 20 cases, one grade 1 flat foot and one grade 1 cavus foot. The hindfoot was normal in 20 cases, valgus in 29 and varus in one.

The forefoot morphology was Egyptian in 22 cases, Greek in 24 and square in 4. The valgus deformity was often severe, with an average angulation of 47.6° (range : 20° to 60°). Valgus deformity was absent in only four cases. The average metatarsus varus in this series was 15.2°. The average angle between the first and fifth metatarsals was 31.1°. No osteoarthritis of the interphalangeal joint was noted. The metatarsal formula was index plus-minus in 28 cases, minus in 12 and plus in 10. There was in all cases a symptomatic pseudoexostosis on the medial aspect of the hallux MP joint. All patients used a shoe insert preoperatively ; all had limitation in their activities of daily living.

Methods

All patients were reviewed at follow-up with radiographs of both feet, including a weight bearing dorsal plantar view and standard AP and lateral views of the operated foot. The average follow-up was 12 months.

A record was created for each foot including surgical history, plus Kitaoka's criteria (12), clinical and podoscopic examinations, pre-operative radiographs and an evaluation of postoperative results. These records included elements of the operative report, complications and subjective results. Radiological measurements were made with the Imagika® Software on digitised radiographs. All data were stored in a spreadsheet and then treated with Excel® and Statistica® softwares. Statistical analysis was made using the Chi squared test, Fisher's test, Pearson's test, and Student's test with Yate's correction for small series.

Surgical technique

After locoregional anaesthesia (44 popliteal nerve blocks and 6 spinal anaesthesias), the operation was performed with a tourniquet. The procedure lasted 45 minutes on average. The metatarsophalangeal joint was approached through a medio-dorsal longitudinal incision (1), curved in the region of the metatarsal head for better exposure. Dissection was continued proximally.

The arthrodesis instrumentation (fig 1, 2) comprised of two drills (ZIMMER®) :

- A concave drill for the head of the first metatarsal.
- A convex drill for the base of the first phalanx of the great toe.

These drills are concentric and 18 to 22 mm in diameter for the metatarsal and 14 to 18 mm for the phalanx.

Soft tissue release on the lateral side was done in case of valgus of the great toe, to re-position the sesamoids under the metatarsal head.

The mode of preparation of the articular surfaces depended on the length to be restored (7), the objective being to achieve equal length between first and second toe. When no reduction in length of the first toe was necessary, we simply removed the cartilage and freshened the underlying bone, which was easily achieved with the set of concentric drills. The centre of the head of the first metatarsal was first located. A pin was then inserted through this point in the axis of the metatarsal, then another pin into the phalanx. The drill was centered over the pin and the head of the first metatarsal was freshened to so as to remove all cartilage (fig 1). The same was done on the first phalanx. The opposing bony surfaces were congruent and allowed easy setting at the required angle. Pridie's perforations were made through both surfaces. Fixation was achieved, using an axial AO small fragment screw (4 mm) as per Girard *et al* (6) and/or pins or staples (fig 2).

In one case of lengthening of the great toe, we used a cortico-cancellous graft harvested from the contralateral fused hallux.

The position selected for arthrodesis was carefully calculated with the technique of Méary (15) for both horizontal and sagittal planes. In the horizontal plane, the goal was to achieve a physiological valgus of 15-20° for men and 20-25° for women. In the sagittal plane, the selected dorsiflexion of the MP joint was 20° for men and 25-30° for women. In addition shoe wearing habits, the usual heel height, and the patient's wishes were taken into account.



Fig. 1. — Intra-operative view showing the concave drill used for preparation of the head of the first metatarsal (above) and the convex drill used for preparation of the base of the first phalanx (below).

In cases with osteoporosis, plate fixation was performed, and an antirotation pin was used in 9 patients.

Soft tissue release on the lateral side and over the sesamoids wherever severe valgus was present, allowed repositioning of the metatarsal head over its sesamoids. Metatarso-phalangeal arthrodesis was rarely performed as an isolated procedure. It was combined with :

- Weil's osteotomy on the second metatarsal in 3 cases, on the third metatarsal in 2 cases.
- Basal osteotomy of M2, M3 and M4 in one patient.
- Lelièvre's resection arthroplasty (M2, M3, M4 and M5) in 7 cases (11).

- Interphalangeal joint arthroplasty of the second ray (5 cases), the third (4 cases) and the fourth (4 cases).
- Lengthening of extensor tendons, performed in 8 cases on the second toe, in 7 on the third toe, in 5 cases on the fourth toe.

Walking with a weight-relieving shoe was allowed immediately but full weight bearing was delayed until radiological fusion and was allowed about day 45th.

Antithrombosis prophylaxis with low molecular weight heparin (LMWH) during the first 10 days was systematic.



Fig. 2. — Pre- and postoperative radiographs of a patient who underwent metatarsophalangeal fusion of the hallux with preparation of the opposing bony surfaces with a set of concentric drills and fixation with one axial screw supplemented with an antirotation pin.

RESULTS

Complications

No perioperative complications were noted. Postoperative oedema was usual and subsided on average two months after weight bearing. Two cases of reflex sympathetic dystrophy (4%) were observed, with slow recovery despite calcitonin treatment. Four delayed unions, complicated by superficial sepsis, were observed, in patients with RA receiving high doses of steroids. They healed quickly with local treatment. Partial fusion was noted in 6 cases. It was asymptomatic and did not

alter positioning. Screw breakage without any adverse consequences was noted in one case.

Overall results

Subjectively, 80% of operated patients were very satisfied (40 cases), 16% satisfied or very much improved (8 cases) and 4% unsatisfied (2 cases).

Objectively the average postoperative Kitaoka score was 84/100 (range, 65 to 90). The grading was excellent with a Kitaoka score 85 to 100 in 72% of cases ; it was good with a Kitaoka score 70 to 84 in 20%, fair with a Kitaoka score of 60 to 69 in 8%. No patient had a score under 60, corresponding to a poor result.

Functional results

Pain at the metatarsophalangeal joint disappeared in 96% of cases, whatever its aetiology. No sign of interphalangeal degeneration was noted. Metatarsalgia disappeared in all cases and most of the patients were able to wear comfortable shoes. Daily activities became normal in 80% of cases. Analysis of results demonstrated a shift to a square foot type in 32 cases, a Greek foot in 14 and an Egyptian foot in 4, versus 4, 24 and 22 respectively, pre-operatively.

Radiological results

Correction of the valgus deformity of the great toe was achieved in all cases with an angle M1-P1 averaging 18° (range : 5-30°). In the horizontal plane, the valgus angulation of the great toe was optimal or acceptable in 98% of cases ; there was slight misalignment in 2%. In the sagittal plane, the metatarsophalangeal orientation was correct in 96% of cases. The average dorsiflexion was 25° (range : 15-35°). The MP joint was fused in 44 cases ; there were 6 cases of asymptomatic absence of bone fusion. No interphalangeal osteoarthritis was noted. The postoperative metatarsus varus was improved by 8.8°, since the average post-operative M1-M2 angle was 7.1°.

DISCUSSION

Indications

The indications for MP fusion of the hallux in this series were similar to other studies. The indication was failure of previous surgery for hallux varus in 28%. The corresponding figures in previous studies have ranged from 17% to 46% (1, 6, 19, 20).

The other indications were osteoarthritis of the MP joint, symptomatic hallux rigidus and rheumatoid arthritis .

For Fitzgerald and Wilkinson (4) hallux valgus is an indication of choice when the deformity is severe or is associated with metatarsalgia.

Analysis of the results demonstrates, in our series and in others (6, 16) that fusion gives better results as a primary operation than as a revision operation, and gives better results in hallux rigidus than in RA.

Surgical approach

Some surgeons (5, 16, 18) prefer a dorsal approach, to avoid problems with shoe wear and the risk of nerve damage in cases of re-operation. We nevertheless used the medial approach, as did Curvale *et al* (1), Girard *et al* (6), Rosset *et al* (19) or Tomeno and Kaddem (20).

Preparation of the surfaces can be obtained by simple freshening (6), but varied from case to case, sometimes requiring a bony resection (19, 20). As Groulier *et al* (7) and Curvale *et al* (1) have shown, preparation of the bony surfaces may be conditioned by a necessary reduction of hallomegaly : when the forefoot is square or greek, removing the articular cartilage is sufficient. When there is considerable hallomegaly, a limited resection with two parallel cuts makes shortening possible, as well as correct positioning for insertion of the screw, achieving good stability.

Positioning

In the horizontal plane, a physiological valgus of the great toe, of at least 15° is essential ; it should be 20° in women. Fitzgerald (4) considers that the

valgus angulation must be between 20° and 30° ; valgus angulation smaller than 15° is associated with pain or problems at the interphalangeal joint (4, 6). In our series, the postoperative valgus angulation of the great toe was on average 18°.

Many patients presented with a major metatarsus varus deformity, which was corrected. Metatarsus varus should be corrected intra-operatively by restoring the function of the oblique abductor (20), when the first metatarsocuneal joint is mobile. Coughlin and Mann (2) believe the metatarsocuneal joint should be tested before fixing the metatarsophalangeal fusion, to make sure the varus can be corrected. If this not possible, basal osteotomy may have to be performed on the first metatarsal bone. As an alternative, Fitzgerald (4) suggested increasing the valgus angulation in the hallux to avoid friction between the first toe and the shoe.

In the sagittal plane, dorsiflexion in the metatarsophalangeal should be 15° to 20° in men and 25° to 30° in women (7, 10). Insufficient dorsiflexion, reported in 4% on average in the literature, generally induces pain over the plantar surface of the distal epiphysis of P1, whereas an excess of dorsiflexion, reported in 7% to 14% of cases induces a problem with the shoe at the dorsum of the interphalangeal joint and at the same time reduces weight bearing on the pulp of the great toe, and the other rays (4).

In the horizontal plane, it is essential, in order to preserve the weight bearing function of the pulp, to correct any axial rotation of the great toe. For the same reason, it is important to avoid rotation during fixation. Girard *et al* (6) have pointed out that desired position is easily achieved if the interphalangeal joint is flexed during tightening of the screw.

Fusion fixation

Various authors have used different means for osteosynthesis : Ghana *et al* (5) used chromium catgut, Coughlin and Mann (2) used large pins, Tomeno and Kaddem (20) and Rosset *et al* (19) used transverse pins, Groulier *et al* (7) and Girard *et al* (6) used an axial screw, occasionally supplemented with a pin (7) and even in some cases a mini external fixator (1, 19, 20).

The fixation has to be solid : the screw must therefore be long enough. If a small cancellous screw is implanted, the whole thread must be in the phalanx, beyond the level of the metatarsal head in order to ensure compression. Osteoporosis has sometimes made it necessary to use one or two supplementary pins, as the screw did not control axial rotation sufficiently.

We did not use postoperative plaster cast immobilisation, but we advise using it if the fixation is unreliable ; immobilisation lasted for 4 to 6 weeks for Ghana *et al* (5) and Coughlin and Mann (2). We think it is sufficient to defer weight bearing for 6 weeks and, subsequently to allow walking with rigid shoes.

Treatment of associated forefoot deformities

As others (7), we recommend global treatment of all problems, especially for static problems of the second ray (subluxation of MTP2, hammer toe). In the case of the rheumatoid forefoot, treatment of the first ray prevails (11, 14), but when articular destruction is more diffuse, resection of the 2nd to 5th MT heads (11) is recommended (7 out of 9 RA cases in our series).

Complications

Non-specific complications are reflex sympathetic dystrophy (2% in the literature, 4% in our series), phlebothrombosis (1 to 2%), post-operative infections (0.5 to 8%). Non-unions represent a more specific complication. Their rate reportedly varies between 2% and 29% (1, 2, 5, 6, 10, 14, 19, 20).

The average infection rate in the literature is 14% ; it does not seem to be influenced by the type of osteosynthesis. There were six cases of infection in our series (12%). Following deep infection, a re-operation is frequently necessary (19, 20).

Ghana *et al* (5) using chromium catgut reported 10% nonunions ; Girard *et al* (6) using a large axial screw reported 9% nonunions. Non union is often merely a radiological finding with no functional correlation. Coughlin and Mann (2) mentioned fibrous union without pain, Moynihan (16) reported pain in one out of three nonunions. In our series, 6 cases of radiological nonunions were asympto-

matic. In 17 cases of non union out of 18, Groulier *et al* (7) noted that the surfaces had been prepared with concentric drills. They believe that the more extensive approach required by the use of these drills might compromise the vascularisation of the bone ends.

Global results

The rate of good or excellent results in different series ranges from 73% to 88% (1, 6, 19, 20) ; it was 92% in our series. Metatarsophalangeal pain was relieved in 96% of cases in our series. This is in agreement with data in the literature : 62% to 91% (6, 19, 20). Residual pain may be related to non-union or persistence of a metatarsus varus, leading to friction on the medial side of the shoe. Pain in the interphalangeal joint of the hallux was present in 15% of cases in our series, and in 3% to 25% in other series (6, 16, 19, 20). Pain associated with joint stiffness is rare (2 to 5%). Degenerative radiological changes are often asymptomatic. Pain may be secondary to excessive motion of the interphalangeal joint, as this joint becomes the only one solicited during walking. It is frequently encountered when positioning of the metatarsophalangeal has been defective, with insufficient valgus (4, 6), inducing a painful conflict with the shoe. Metatarsalgia was reportedly reduced or disappeared in 63% to 75% in other series (96% in our study). For Fitzgerald (4), MP arthrodesis is an operation of choice when the hallux valgus is associated with metatarsalgia. The latter will persist however if fusion of the MP joint is done with more than 30° dorsiflexion (19). In our series we noted that metatarsalgia was relieved when the sesamoids had been correctly repositioned. Weight bearing on the great toe is satisfactory in 80% of cases (8). Wearing normal shoes is reportedly difficult for many patients (6). In our series 66% of patients could wear normal shoes but oedema delayed their use for three months.

CONCLUSION

Arthrodesis of the metatarsophalangeal joint of the hallux remains a method of choice to treat

severe deformities as seen in rheumatoid arthritis and in cases with recurrent hallux valgus deformity, iatrogenic hallux varus or hallux rigidus. It does not result into significant functional impairment insofar as the talocrural and interphalangeal joints are intact. The technique using a set of concentric drills allows optimal positioning of the great toe ; it appears to give a high rate of incomplete fusion but without any repercussion on the final functional outcome within the time limits of this study.

A study on larger series will be needed to confirm the efficiency of this technique using concentric drills.

A less extensive approach and careful attention to details of the operative technique would probably improve the fusion rate.

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