Fixation of Mitchell's osteotomy with bioabsorbable pins for treatment of hallux valgus deformity

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Abstract We hypothesised that the use of bioabsorbable pins in Mitchell's osteotomy would improve the outcome of patients treated for hallux valgus deformity. A total of 68 patients underwent Mitchell's osteotomy to correct hallux valgus deformity: 33 patients (group A) underwent Mitchell's osteotomy augmented with bioabsorbable pins and 35 patients were treated with the classic operative procedure (group B). Hallux valgus angle (HVA), intermetatarsal angle (IMA), the American Orthopaedic Foot and Ankle Society (AOFAS) hallux metatarsophalangeal-interphalangeal scale and the visual analogue score (VAS) for pain were measured preoperatively and postoperatively. There was no statistically significant difference between the two groups as far as the improvement of the IMA, HVA and AOFAS scale were concerned. Patients of group A had significantly less postoperative pain and returned to their previous activities earlier than patients of group B. The use of the pins did not improve the final outcome of the osteotomy. However, it allowed for faster rehabilitation due to less postoperative pain.

Résumé nous faisons l'hypothèse que l'utilisation de broches résorbables dans la technique d'ostéotomie de type Mitchell doit améliorer les suites des patients traités pour un hallux valgus. 68 patients ont bénéficié d'une ostéotomie

de type Mitchell pour corriger un hallux valgus, 33 patients (groupe A) ont été traités selon cette ostéotomie avec des broches résorbables et 35 patients (groupe B) ont été traités selon la méthode classique. L'angle de l'hallux valgus (HVA), l'angle intermétatarsiens (IMA), le gradient métatarsien et interfalangien AOFAS ainsi que la douleur mesurée par échelle analogique ont été mesurés en préopératoire et en postopératoire. il n'y a pas de différences significatives entre ces deux groupes en ce qui concerne L'IMA, L'HVA et L'AOFAS. Les patients du groupe A ont, de façon significative, moins de douleur post-opératoire et un retour à l'activité plus rapide que les patients du groupe B. L'usage de ces broches améliore donc le devenir de ces patients permettant une rééducation plus rapide du fait de la diminution des douleurs post-opératoires.

Introduction

Hallux valgus deformity is characterised by subluxation of the first metatarsophalangeal joint (MTPJ) with lateral deviation of the great toe and medial deviation of the first metatarsal with a medially prominent first metatarsal head [15]. The exact aetiology of this entity remains even nowadays largely unknown and many theories have been proposed to give a reliable explanation [12]. It seems that imbalance in the abductor and adductor muscles, constricting footwear and heredity are all factors that contribute to the appearance of this pathological condition. It is interesting that hallux valgus occurs almost exclusively in shoe-wearing societies [7]. There are many procedures described in the literature for correction of the deformity of hallux valgus, and these are typically undertaken in an effort to diminish pain, improve function, enable shoe wear and prevent the development of problems localised to the lesser toes [6].

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One of the most commonly used surgical interventions is the one proposed in 1945 by Mitchell et al. [18]. This procedure consists of (a) removal of the medial eminence, (b) an osteotomy of the distal portion of the first metatarsal shift, (c) lateral displacement and angulation of the capital fragment and (d) medial capsulorrhaphy. In their initial series of 100 osteotomies, Mitchell et al. reported satisfactory results ranging from 74 to 94% [18]. However, since then, numerous authors have reported quite inferior results, especially after longer follow-up periods [7]. The main long-term complication of the original Mitchell's osteotomy is the recurrence of hallux valgus with medial eminence pain [7]. Other complications include metatarsalgia that is due to dorsiflexion malunion of the distal fragment or extensive shortening of the metatarsal.

Use of K-wires or other means of internal fixation, like the Herbert bone screw, replacing or enhancing the classic suture fixation, has been reported in many series [3, 23]. We hypothesised that the use of bioabsorbable pins in Mitchell's osteotomy would improve the outcome of patients treated for hallux valgus deformity.

Patients and methods

Between January 2003 and January 2007, 68 consecutive patients (71 feet) underwent Mitchell's osteotomy to correct hallux valgus deformity: 33 patients (35 feet) (group A) underwent Mitchell's osteotomy augmented with the use of bioabsorbable pins made of poly(*p*-dioxanone) (Fig. 1); 35 patients (36 feet) were treated with the standard operative procedure with stabilisation of the osteotomised fragments only with a suture and formed the control group of this study (group B). One experienced surgeon (NE) performed all operations. Even though there was no randomisation protocol, pins were used in a random way. Radiographic signs of established osteoporosis were especially a suggestive (but not unquestionable) criterion to use pins.

Fig. 1 Bioabsorbable pins made of poly(*p*-dioxanone) were used for the augmentation of Mitchell's osteotomy

There were no differences between the two groups with respect to age and gender (Table 1).

Anteroposterior and lateral weight-bearing radiographs were taken preoperatively, with measurement of the hallux valgus angle (HVA) and intermetatarsal angle (IMA) of the great toe to document the initial deformity. The method of measuring these angles has been well described [17]. Based on patient records, a preoperative score for the American Orthopaedic Foot and Ankle Society (AOFAS) hallux metatarsophalangeal-interphalangeal scale was assigned [13].

In 23 patients of group A (23 feet) and 18 patients (18 feet) of group B, pain was additionally quantified with a 10-point visual analogue scale (VAS) (with 0 points indicating no pain and 10 points severe pain) preoperatively and at the second postoperative follow-up appointment (four weeks after surgery). The overall duration of convalescence was recorded in the form of time elapsed from the operation to the patient's return to normal previous daily activities.

At surgery, a typical Mitchell's osteotomy [18] was performed in all patients. In the patients of group A, after stabilisation of the osteotomised fragments with the suture and before the medial capsulorrhaphy, a hole was created using a 1.5-mm K-wire, through the osteotomy, beginning at the medial cortex of the metatarsal shaft proximal to the osteotomy and ending at the lateral side of the osteotomised head of the metatarsal (Fig. 2a). Using the instrumentation provided, the poly(*p*-dioxanone) pin was inserted into the full length of the hole. The portion of the pin that protruded was removed (Fig. 2b). Following this, medial capsulorrhaphy was performed.

The postoperative treatment was identical in both groups. All patients received a standard bunion dressing with extra support by Zimmer splint for the first postoperative days (Fig. 3) and were allowed full weight-bearing as tolerated in a special shoe for a period of two to four weeks. Then, they advanced to comfortable shoe wear. Each patient was evaluated at regular intervals, typically at two, four and 12 weeks and six months. In addition, all patients received at least one long-term follow-up exam and were rated according to the AOFAS hallux metatarsophalangeal-interphalangeal scale [13].

Anteroposterior and lateral weight-bearing radiographs were taken preoperatively, at the first postoperative appointment (two weeks after surgery) and at the follow-up appointments (Fig. 4) to measure the amount of correction and its maintenance and the consolidation of the osteotomy as well as to determine any evidence of sterile sinus formation, infection, osteolysis and/or fixation failure.

To investigate if osteolysis was present, the diameter of the pin track was measured and any enlargement was evaluated and registered. Osteolysis was considered to be

Table 1 Basic patient demographics and preoperative–postoperative parameters studied

	Group A (bioabsorbable pins)	Group B (control group)	<i>P</i> value (95% CI)
Patients (feet)	33 (35)	35 (36)	<0.05 ^{NS}
Mean age (range)	46 (21–68)	48 (24–69)	<0.05 ^{NS}
Side (left/right)	18/17	13/23	0.23 ^{NS}
Men/women	0/33	1/35	1.000 ^{NS}
Preop. IMA (SD)	13 (2.1)	12.2 (1.6)	0.076 ^{NS}
Postop. IMA (SD) ^a	7 (1.8)	6.6 (1.3)	0.325 ^{NS}
Postop. IMA (SD) (latest FU)	9 (1.2)	9.2 (1.8)	0.584 ^{NS}
Preop. HVA (SD)	28.5 (8.1)	31.1 (8.2)	0.183 ^{NS}
Postop. HVA (SD) ^a	19.4 (5.2)	17.8 (4.1)	0.331 ^{NS}
Postop. HVA (SD) (latest FU)	20.6 (3.1)	21 (3.8)	0.629 ^{NS}
Preop. AOFAS (SD)	42.1 (13.2)	46 (9)	0.138 ^{NS}
Postop. AOFAS (SD) (latest FU)	89.3 (11.8)	86.2 (13)	0.296 ^{NS}
Preop. VAS (SD)	5.72 (2.6)	6.1 (2.9)	0.661 ^{NS}
Postop. VAS (SD) (4 weeks postop.)	3.84 (1.3)	5 (0.8)	0.002*
Duration of convalescence (weeks) (SD)	7.85 (2.40)	9.2 (1.8)	0.059 ^{NS}

NS not statistically significant, *FU* follow-up

*Statistically significant

^a X-ray examination at the first postoperative appointment

mild if the area of involvement measured 5 mm or less and to be more severe if it measured more than 5 mm.

Statistical analysis

Parametric and non-parametric tests (paired and unpaired *t*-test, Mann-Whitney U test, Fisher's exact test) were used as appropriate to assess differences between groups. Differences were considered significant at *P* values below 0.05.

Results

All patients but one of this series were women. The mean age was 46 years (21–68 years) for group A and 48 years (24–69) for group B. The mean follow-up was 18 months (12–32) and 24 months (12–36) for groups A and B, respectively. The mean intermetatarsal angle significantly decreased from 13 ± 2.1 preoperatively to $7 \pm 1.8^\circ$ at the first postoperative X-ray for group A and from 12.2 ± 1.6

preoperatively to $6.6 \pm 1.3^\circ$ at the first postoperative X-ray for group B. Similarly, the average hallux valgus angle significantly decreased in group A from 28.5 ± 8.1 preoperatively to $19.4 \pm 5.2^\circ$ at the X-ray of the first postoperative appointment and in group B from 31.1 ± 8.2 preoperatively to $17.8 \pm 4.1^\circ$ postoperatively. Consequently, there was no statistically significant difference between the two groups as far as the immediate postoperative correction of the intermetatarsal and hallux valgus angles were concerned. By three months postoperatively, all patients showed evidence of consolidation, with gradual disappearance of the osteotomy line and without any evidence of loss of correction. Even though there was a tendency towards increase of the intermetatarsal and hallux valgus angles that were measured at the latest follow-up in both groups (in comparison with the values obtained at the first postoperative X-ray), the difference between the two groups was not statistically significant (Fig. 5). Patient demographics as well as preoperative and postoperative values are summarised in Table 1.

Fig. 2 a Using a 1.5-mm K-wire a hole was created through the osteotomy, beginning at the medial cortex of the metatarsal shaft proximal to the osteotomy and ending at the lateral side of the osteotomised head of the metatarsal. **b** The bioabsorbable pin was inserted into the full length of the hole. The portion of the pin that protruded was removed

Fig. 3 Postoperatively all patients received a standard bunion dressing with extra support by Zimmer splint

Radiographically, the development of a small area of osteolysis was evident in one patient. More specifically, a mild osteolytic area (less than 5 mm) was seen at the entry point of the bioabsorbable pin, at the medial aspect of the proximal fragment of the osteotomy. Subsequent radiographs showed that this area did not progress in size. There were no associated clinical complaints. There was no evidence of avascular necrosis in either patient group.

At latest follow-up, there was a significant increase in the AOFAS hallux metatarsophalangeal-interphalangeal score compared to preoperative values: 89.3 ± 11.8 from 42.1 ± 13.2 for group A and 86.2 ± 13 to 46 ± 9 for group B. However, the difference between the two groups was not statistically significant.

The mean pain score improved from 5.72 ± 2.6 points preoperatively to 3.84 ± 1.3 points four weeks following surgery for group A and from 6.1 ± 2.9 to 5 ± 0.8 points for group B. The difference between the two groups as far as

the postoperative pain was concerned was statistically significant (Table 1).

In group A 20 patients and in group B 18 patients were able to give specific answers as far as the duration of convalescence was concerned. With the available numbers, patients of groups A and B returned to their previous activities in 7.85 ± 2.40 and 9.2 ± 1.8 weeks, respectively ($P=0.059$).

No serious complications were recorded in either group. In four patients there was a bone cortex failure at the time of the suture tightening. In all of these patients the osteotomy had been augmented with biodegradable pins. There was one case of algodystrophy in group B and that patient received the appropriate treatment. No sinus formation or infection was reported until the time of the latest follow-up.

Discussion

It is estimated that approximately 33% of individuals in shod populations have some degree of hallux valgus [21]. Correction of a hallux valgus deformity through an osteotomy of the distal end of the first metatarsal was reported first by Reverdin [20] in 1881. Since then, more than 100 techniques have been described.

Mitchell et al. [18] popularised the technique of biplanar osteotomy of the distal end of the metatarsal, which achieves lateral and plantar displacement as well as shortening of the first metatarsal. In the original operation the site of the osteotomy is stabilised with a circumferential suture placed through two parallel drill holes and tied dorsally [18].

Fig. 4 Preoperative (*left*), immediate postoperative (*middle*) and 12 weeks postoperative (*right*) anteroposterior weight-bearing radiographs of a patient treated with bioabsorbable pin

Fig. 5 Changes at the intermetatarsal angle (*chart 1*) and the hallux valgus angle (*chart 2*) in the two patient groups. *Left columns*: preoperative values, *middle columns*: values obtained at the first postoperative appointment, *right columns*: values obtained at the latest follow-up

However, failure to control the distal fragment during healing of the osteotomy may lead to malunion of the metatarsal head in dorsiflexion, causing weight transference laterally and metatarsalgia [2]. Thus, enhancement of the fixation with Kirschner wires [23], Steinmann pins [2], staples [4] or screws [3] has been tested in numerous series with good results.

To our knowledge, there is no previous report of the use of bioabsorbable pins in the fixation of Mitchell's osteotomy for hallux valgus deformity. We hypothesised that augmentation of the osteotomy with bioabsorbable pins would offer better results than the classic procedure with suture stabilisation only.

Bioabsorbable implants offer the advantage of elimination of the need for removal of hardware as well as the gradual transfer of stress to bone [9]. These implants provide fixation during the early phase of healing, then lose strength from hydrolysis and eventually are metabolised [16]. Additionally, fixation with bioabsorbable pins eliminates the inconvenience and the potential risks associated with protruding wires such as pain in the surrounding skin, infection and limitation of the ability of the patients to bathe. Moreover, postoperative special shoes are difficult to wear because of the protruding wires. Conclusively, patients are more comfortable in the early postoperative period with the use of bioabsorbable pins.

The possible loss in the mechanical stability and the biological reaction of the host to the implant are the two main potential disadvantages. Ideally, the implant should maintain fixation strength during the interval required for the biological union to develop. Some authors believe that bioabsorbable implants are best in applications with low load, rapid healing and fixation of small osseous segments because of their weaker mechanical properties than metallic devices and their progressive loss of strength [19]. Although compression is often desirable across a fracture or osteotomy interface, it is clear that compression cannot be achieved by use of bioabsorbable pin fixation. However, it is thought that a slight amount of motion may be helpful in the healing process due to the bone callus that develops, possibly further splinting the site [5]. At four weeks the

strength of the poly(*p*-dioxanone) that was used in this study has been reported to be 50–70% of the strength at the time of the insertion, with 25% remaining at six weeks [25]. Another study of 1.3-mm diameter poly(*p*-dioxanone) pins implanted in the femora of mature rabbits showed that the strength of the pins was more than 80% at four weeks and 55% at 5 weeks [1].

The biological reaction of the host to the implant is an important consideration. Tissue reactions to the presence of an implanted material have been documented for both metals [24] and bioabsorbables [8, 11]. In the case of bioabsorbable polymers, such reactions manifest as granulomas, sterile sinus formation, osteolysis and pronounced fibrous encapsulation [8, 11]. Several predisposing factors including implant-related, site-related and patient-related causes are known [10]. Poly(*p*-dioxanone) is a relatively fast absorbing homopolymer, but its incidence of foreign body reaction is low. In the literature all reports of the use of poly(*p*-dioxanone) in the correction of hallux valgus deformity are related to chevron osteotomy [10, 14, 22, 25]. In these series the reported incidence of osteolytic reactions ranges from 0 to 9%. In our study there was no sinus formation or granulomas up to the latest follow-up. Radiographically, the development of a small area of osteolysis was evident in one patient. Subsequent radiographs showed that this area did not progress in size. There were no associated clinical complaints.

However, the use of the biodegradable pins did not yield better results as far as the studied parameters were concerned in comparison with the group of patients that were treated with the classic Mitchell's osteotomy. In both patient groups there was a tendency to recurrence of the deformity (IMA and HVA) at the latest follow-up. However, the difference between the two groups never reached statistical significance. On the other hand, patients of group A had significantly less pain in the early postoperative period (four weeks after surgery). This may be attributed to the better stability at the fracture site. Additionally, it could be speculated that the lower degree of postoperative pain resulted in faster postoperative rehabilitation. Indeed, patients of group A returned faster

to their previous activities, even though this difference was at the borderline of statistical significance.

In our practice, bioabsorbable pins are particularly useful in the treatment of osteoporotic patients with hallux valgus deformity. In these cases, primary stabilisation of the osteotomised fragments with only a suture can be problematic and augmentation of the fixation with a bioabsorbable pin often offers a reliable solution.

We are aware that this study is characterised by a number of limitations inherent in studies of a retrospective nature. Firstly, this is a non-randomised study that deals with patients of a wide age range. Secondly, the relatively small number of patients recruited inevitably weakens the power of the study. Thirdly, the follow-up period is relatively short and long-term complications are still to be identified and reported. Finally, parameters that can influence the outcome like smoking habits, drug intake, underlying medical conditions (diabetes, etc.) were not separately investigated.

Nevertheless, it is concluded from this study that the use of bioabsorbable poly(*p*-dioxanone) pins for the enhancement of Mitchell's osteotomy is a reliable treatment option. There was no foreign body reaction and there was only one case of mild osteolysis with no further consequences. Even though the usage of the pins did not improve the final outcome of the osteotomy, it seems that it allowed for faster rehabilitation due to less postoperative pain. Larger prospective randomised trials are needed to confirm the current findings.

References

- Bhatia S, Shalaby SW, Powers DL, Lancaster RL, Ferguson RL (1994) The effect of site of implantation and animal age on properties of polydioxanone pins. *J Biomater Sci Polym Ed* 6 (5):435–446
- Blum JL (1994) The modified Mitchell osteotomy-bunionectomy: indications and technical considerations. *Foot Ankle Int* 15 (3):103–106
- Bonner AC Jr (1986) Rigid internal fixation of the Mitchell-Hawkins osteotomy/bunionectomy with the Herbert Bone Screw. *J Foot Surg* 25(5):390–393
- Briggs TW, Smith P, McAuliffe TB (1992) Mitchell's osteotomy using internal fixation and early mobilisation. *J Bone Joint Surg Br* 74(1):137–139
- DeFronzo DJ, Landsman AR, Landsman AS, Stern SF (1991) Austin bunionectomy with 3M Staplizer fixation. An assessment of 20 cases. *J Am Podiatr Med Assoc* 81(3):140–149
- Dhukaram V, Hullin MG, Senthil Kumar C (2006) The Mitchell and Scarf osteotomies for hallux valgus correction: a retrospective, comparative analysis using plantar pressures. *J Foot Ankle Surg* 45(6):400–409
- Fokter SK, Podobnik J, Vengust V (1999) Late results of modified Mitchell procedure for the treatment of hallux valgus. *Foot Ankle Int* 20(5):296–300
- Frederick J, Hulst TJ, Sundareson AS (1996) Foreign-body reaction to absorbable fixation devices. *J Am Podiatr Med Assoc* 86(8):396–398
- Giannini S, Ceccarelli F, Moroni A, Spezioli G (1994) Bioreabsorbable osteosynthesis devices in foot fractures. In: Kwok-sui L, Leung-kim H, Ping-chung L (eds) *Biodegradable implants in fracture fixation*. World Scientific, Hong Kong
- Gill LH, Martin DF, Coumas JM, Kiebzak GM (1997) Fixation with bioabsorbable pins in chevron bunionectomy. *J Bone Joint Surg Am* 79(10):1510–1518
- Kalla TP, Janzen DL (1995) Orthosorb: a case of foreign-body reaction. *J Foot Ankle Surg* 34(4):366–370
- Kato T, Watanabe S (1981) The etiology of hallux valgus in Japan. *Clin Orthop Relat Res* 157:78–81
- Kitaoka HB, Alexander IJ, Adelaar RS, Nunley JA, Myerson MS, Sanders M (1994) Clinical rating systems for the ankle-hindfoot, midfoot, hallux, and lesser toes. *Foot Ankle Int* 15(7):349–353
- Lavery LA, Peterson JD, Pollack R, Higgins KR (1994) Risk of complications of first metatarsal head osteotomies with biodegradable pin fixation: Biofix versus Orthosorb. *J Foot Ankle Surg* 33(4):334–340
- Mann RA, Coughlin MJ (1981) Hallux valgus—etiology, anatomy, treatment and surgical considerations. *Clin Orthop Relat Res* 157:31–41
- Middleton JC, Tipton AJ (2000) Synthetic biodegradable polymers as orthopedic devices. *Biomaterials* 21(23):2335–2346
- Miller JW (1974) Distal first metatarsal displacement osteotomy. Its place in the schema of bunion surgery. *J Bone Joint Surg Am* 56(5):923–931
- Mitchell CL, Fleming JL, Allen R, Glenney C, Sanford GA (1958) Osteotomy-bunionectomy for hallux valgus. *J Bone Joint Surg Am* 40-A(1):41–58, discussion 9–60
- Papagelopoulos PJ, Giannarakos DG, Lyritis GP (1993) Suitability of biodegradable polydioxanone materials for the internal fixation of fractures. *Orthop Rev* 22(5):585–593
- Reverdin J (1881) De la déviation en dehors du gros orteil et de son traitement chirurgical. *Trans Internat Med Congress* 2:408–412
- Sim-Fook L, Hodgson AR (1958) A comparison of foot forms among the non-shoe and shoe-wearing Chinese population. *J Bone Joint Surg Am* 40-A(5):1058–1062
- Small HN, Braly WG, Tullos HS (1995) Fixation of the Chevron osteotomy utilizing absorbable polydioxanone pins. *Foot Ankle Int* 16(6):346–350
- Teli M, Grassi FA, Montoli C, Moalli S, Pazzaglia UE (2001) The Mitchell bunionectomy: a prospective study of 60 consecutive cases utilizing single K-wire fixation. *J Foot Ankle Surg* 40 (3):144–151
- Thomas KA, Cook SD, Harding AF, Haddad RJ Jr (1988) Tissue reaction to implant corrosion in 38 internal fixation devices. *Orthopedics* 11(3):441–451
- Winemaker MJ, Amendola A (1996) Comparison of bioabsorbable pins and Kirschner wires in the fixation of chevron osteotomies for hallux valgus. *Foot Ankle Int* 17(10):623–628