Fixation of the Opening Wedge Calcaneal Osteotomy with Ultrasonic Bioresorbable Polymer Pin Utilizing Bone Welding Principle

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Statement of Purpose

The purpose of this case series is to investigate new safe and effective methods of internal fixation for the opening wedge calcaneal osteotomy by utilizing an innovative bioresorbable polymer pin vs traditional screw or plate fixation. There is limited research in the field of foot and ankle surgery regarding fixation using ultrasonic energy for insertion of bioresorbable polymer pins, therefore we believe further studies are necessary in order to explore the benefits with this technique in relation to its safety and efficacy.

Methodology

A retrospective review was conducted on 17 patients that underwent an opening wedge calcaneal osteotomy utilizing ultrasonic bioresorbable polymer pin fixation. All procedures were performed by one surgeon in private practice setting with a follow-up time of 12-32 months. Pre-operative and post-operative radiographs were evaluated for correction of deformity, osseous healing and bone graft incorporation.

Procedure Technique

The procedure is started with an oblique incision approximately 4 cm in length overlying the lateral aspect of the calcaneus to gain access to the site of the osteotomy. An opening wedge osteotomy is made one centimeter proximal and parallel to the calcaneal-cuboid joint and a tri-cortical allograft or titanium wedge graft is inserted sized to the desired level of correction. The use of traditional fixation (screws, plates, press fit bioresorbable pins, etc.) for the opening wedge calcaneal osteotomy presents several complications. These include soft tissue irritation from prominent hardware, loosening or migration of hardware most notable in patients with poor bone quality, and the possible need for a secondary surgery for removal of hardware. (5)

Albeit limited, there have been several studies showing advantages with this bioresorbable polymer pins inserted with ultrasonic energy. Langhoff et al found that new bone formed at the implant to bone interface without any evidence of inflammatory reaction or growth of fibrous tissue, and they observed a lower thermal dose compared to routine drilling within sheep models. (6) These results were also duplicated in craniofacial surgeries which noted no pronounced foreign body reaction, no thermally-induced necrosis with this polymer and decreased surgical time while negating need for secondary surgery for hardware removal. (8,9)

Regarding the strength of this fixation compared to other methods, it has been shown that an ultrasonically implanted 3.5 mm polyactic absorbable pin achieved equal pullout strength as a 5 mm titanium suture anchor after testing in weak bone. (9) Furthermore, Pilling et al showed that the mechanical stability of the ultrasonically introduced pin osteosynthesis was greater than that of traditional screws. (7)

Most notably in the area of foot and ankle surgery, a study by Olms K shows that utilizing ultrasonic bioresorbable polymer pin fixation for chevron osteotomies in HAV deformities has reduced operation times and has avoided the need for hardware removal. (9) Additionally, 100% of patients had normal healing osteotomy at 12 and 24 months post-operatively. Furthermore, 100% of patients had maintained correction at 12 months and 96.7% at 24 months, with none of the patients experiencing a foreign body reaction during the post-operative period.

Results

Of the 17 patients total included in the retrospective case series, upon examination of the post-operative radiographs there was complete healing with no loss of correction, non-union or delayed union noted. Upon clinical examination, there were no observed complications including foreign body reactions or soft tissue irritation.

Discussion

The use of traditional fixation for the opening wedge calcaneal osteotomy presents several risks and complications. Increased dissection, soft tissue irritation from prominent hardware and inadequate compression at the native bone to graft interface are all difficulties associated with traditional fixation techniques. It is in the primary author’s experience that, with use of bioresorbable polymer pins inserted with ultrasonic welding techniques, these limitations are not encountered. The ultrasound induced liquefaction of the pin allows the bioresorbable substance to penetrate into the porous cancellous bone and solidify within 5 seconds thus providing a stable form of fixation in multiple planes. In addition to providing a consistent and stable and reproducible result for this osteotomy, the near zero profile eliminates irritation to the soft tissue structures and the low absorptive profile of the polymer decreases foreign body reactions that plague traditional absorbable fixation. The results of this case series have exceeded our expectations with respect to stability of osteotomy and overall adaptability of the technique with no observed complications thus far and because of this we believe this new technique is an excellent alternative for fixation of the opening wedge calcaneal osteotomy.

Literature Review

The use of traditional fixation (screws, plates, press fit bioresorbable pins, etc.) for the opening wedge calcaneal osteotomy presents several complications. These include soft tissue irritation from prominent hardware, loosening or migration of hardware most notable in patients with poor bone quality, and the possible need for a secondary surgery for removal of hardware. (5)

The ultrasonically activated bioresorbable polymer pin is made up of a Poly-L-lactide 70:30 bioresorbable polymer that when inserted under ultrasonic energy and direct pressure, the polymer liquefies and fills into the porous channels of the cancellous bone structures and subsequently cools and hardens resulting in a stable construct of fixation in multiple planes. (5)

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