Case Report

Surgical Correction of A Deformed Mid-/Hindfoot Using Preoperative 3-D Planning of an Oblique Single-Cut Rotation Osteotomy: A Case Report

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Abstract

Deformities of the mid-/hindfoot are sometimes difficult to fully appreciate using 2D imaging techniques. In these cases, three-dimensional modelling of the affected and mirrored healthy foot and subsequent alignment of healthy structures may better visualize a multidirectional deformity of the foot. In this report we describe preoperative 3-D planning of an oblique single-cut rotation osteotomy of a deformed lateral column of the foot and subsequent surgical treatment using a patient-specific cutting guide. At one-year follow-up, the pain had disappeared and walking with shoes was unlimited.

INTRODUCTION

Preoperative surgical planning of a deformity correction helps providing an optimal surgical outcome. Conventional 2-D projection images, however, provide limited understanding of a deformity, especially in case the deformity is multidirectional. Three-dimensional techniques are available, which model a deformed bone based on a CT scan. This enables exact preoperative virtual planning of an osteotomy and design of a patient-specific cutting guide to transfer the osteotomy to the actual bone during surgery [1-10]. In this case report we describe a previously unreported method for corrective surgery of a deformed lateral column of the foot using a preoperatively planned oblique single-cut rotation osteotomy (OSCR).

CASE PRESENTATION

A 36-year old woman visited our outpatient clinic in 2011 with persisting pain and difficulties with walking after an attempted arthrodesis of the 4th and 5th TMT joint. At age 22, a lengthening arthrodesis of the calcaneocuboid joint was performed for complaints of a flat foot. During physical examination there was pain over the TMT4 and 5 joints. A subsequent surgical intervention resulted in fusion of the pseudarthrosis. Pain was relieved, but walking was still difficult. During gait, weight bearing was over the lateral column of the foot. On physical examination an inverted position of the foot was present due to a plantarflexed and rotated lateral column. Movement of the subtalar joint was limited compared to the other foot, with no eversion and 15 degrees of inversion. There was no compensatory movement in the Chopart joint. There was callus on the lateral side of the foot. Range of motion of the ankle was normal. X rays, and CT, revealed fusion of the CC joint, and fusion of the cuboid with TMT 4 and 5 (Figure 1a).

SURGICAL PLANNING

A high-resolution computed tomography (CT) scan at routine clinical dosage was made of both feet for preoperative planning (Philips Brilliance 64 CT scanner, Cleveland, OH; voxel size 0.45×0.45×0.45 mm, 120 kV, 150 mAs, pitch 0.6). Radiographs (Figure 1a) and a surface rendering of both feet (Figure 1b) did not clearly show the clinical problem. Therefore, the fused bone block of the affected foot (including the calcaneus, the cuboid and the 4th and 5th metatarsal) and the mirrored healthy foot were segmented using custom-made software.4 The calcanei of both feet were aligned to visualize the deformity (Figure 2). It revealed that fusion of the bones was obtained in an abnormal position with the 4th and 5th metatarsals rotated below the foot. Since foot eversion is normally limited to approximately 15° [11], the patient could not compensate for the rotational deformity, which was evidently larger.

The deformity was composed of rotations about respectively the transversal (55.9°) sagittal (3.6°), and vertical axes (9.0°). We envisioned restoring the deformity by a corrective osteotomy of the lateral bone block, and subsequent repositioning of the segment containing the metatarsals with respect to the calcaneus to achieve anatomical alignment. A straight osteotomy, however, would correct only one of the rotations described above and leaves a gap between the osteotomized bone segments. We therefore planned an OSCRO [3,12]. In this procedure, an oblique osteotomy is performed followed by rotation of the metatarsal segment about the axis perpendicular to the osteotomy plane normal (Figure 3). The orientation of the osteotomy and the correction angle (56.4°) are calculated during the preoperative planning procedure [3,4]. The osteotomy is transferred from the virtual 3-D plan to the patient’s bone using a polyamide cutting guide, which tightly fits the bone geometry. The guide was produced using additive manufacturing technology (Amitek Prototyping, De Meern, The Netherlands). Figure (4) illustrates the steps in the operative procedure. Figure (5) shows the pre- and postoperative standing radiographs, and Figure 6 shows the pre- and postoperative pedobarographic images.

**DISCUSSION**

In this paper we introduced a new 3-D planning technique for correcting deformities of the ankle and demonstrated its successful use in a patient case with a stiff lateral column after previous arthrodesis of the Calcaneocuboid and cuboid-TMT 4-5 joints.

Conventional surgical techniques are based on 2-D
radiographs. These images limit appreciation of the deformity, which is a 3-D phenomenon. Judging a deformity using 2-D radiographs is further hampered by over projection of surrounding bones. A three-dimensional bone model, as segmented from CT scans, on the other hand, enable full appreciation of the deformity in 3-D and also allows planning and simulating corrective surgery in which the contralateral side is often used for its high level of symmetry [13].

For our patient we performed an oblique single-cut rotation osteotomy. It enabled correction by a single rotation while the deformity is more complex and was composed of rotations about the sagittal, transversal and vertical axes. The residual errors were limited and mainly due to the fact that soft tissue tension was already high and further rotation towards the planned position were considered intolerable. In the post operative foot position (Figures 5-7), there was minimal varus in the hindfoot and adduction in the forefoot. However, this did not result in complaints or inability to wear shoes. It was therefore not additionally treated.

In the last decade other 3-D planning and repositioning techniques have been proposed since conventional 2-D based techniques have shown to be less accurate and a relation was found between residual malpositioning and clinical outcome [14]. These 3-D techniques achieve reduction by using either navigation equipment [1,15], by inserting a patient-specific wedge into the osteotomy gap [1,2,10], by predrilling holes into the bone which are in agreement with a standard fixation plate [6,7], by using reduction guides before fixation [8], or by using a patient-specific positioning and fixation plate [5,10]. The latter is the most accurate and seems promising for future utilization. However, reduction of large deformities may sometimes need to be compromised to avoid soft tissue issues, as in the current case study. Sophisticated patient-specific solutions may therefore fail for extreme deformities, although recommendable for most other cases.

The purpose of this report was to introduce the potential of the OSCRO for multidirectional reconstructive surgery of the ankle joint. Complex deformities that show angular deformities in sagittal, transversal and coronal planes can be corrected for, by a guided osteotomy and a simple rotation of the bone faces within the cutting plane.

Preoperative virtual planning of an OSCRO helps appreciating the true 3-D anomaly and simplifies surgical treatment of complex deformities, using the contralateral foot as target model. Care should be taken in correcting large deformities, since the planned position may not be feasible as a result of large counteracting soft-tissue forces. When malalignment persists after a bone block arthrodesis the OSCRO can be taken into consideration for realignment surgery.

**CONFLICT OF INTEREST**

The Academic Medical Center wishes to license the software written by JGGD to a third-party company to make the documented type of planning available to other medical institutes.
REFERENCES


