An Innovative Technique Using Computer Navigation to Optimize the Results of High Tibial Osteotomy

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INTRODUCTION

Opening-wedge High Tibial Osteotomy (HTO) has been shown to be an effective procedure to treat mild to moderate osteoarthritis of the medial compartment of the knee in active individuals [1]. It has also become a mandatory surgical adjunct to articular cartilage restoration when there is preoperative malalignment[2]. However, its efficacy is directly correlated with the accuracy of the correction, which must be within 3° of the preoperative target. Achieving this goal is a significant challenge with conventional techniques. Therefore, computer-assisted navigation protocols have been developed; however, they do not adequately address the technical difficulties associated with this procedure [3]. We present an integrated solution dedicated to the opening-wedge HTO. Advantages to the technique we propose include: 1) a minimum number of implanted bone trackers, 2) depth control of the saw, 3) improved 3-D accuracy in the location of the lateral tibial hinge, and 4) micrometric adjustment of the degree of correction.

MATERIALS AND METHODS

A novel integrated system has been developed to address the drawbacks of existing computer-assisted solutions for opening-wedge HTO (Ostesys, Plouzane, France). An improved hip center detection algorithm has been implemented without the necessity of a femoral tracker [4]. All data are displayed on a compact, mobile navigation station in close proximity to the surgical field. The procedure is performed trough a minimally-invasive 5-6 cm skin incision without the need for separate incisions to insert the trackers. Once the key landmarks have been acquired, a novel guide helps to control the depth of the saw (to avoid iatrogenic neurovascular damage) and the location of the external tibial hinge. The navigation software controls the accuracy of the correction including the micrometric bone distraction and final fixation of the tibia. Fixation is accomplished with an internal PEEK implant contained entirely within the tibia that is designed to provide adequate stability of the construct while avoiding the soft tissue irritation associated with external hardware. We have tested this novel osteotomy solution on six cadaveric specimens.

RESULTS

The proof of concept has been completed on all six specimens. The following key points have been validated:

a) Compatibility with a minimally-invasive (5-6 cm) surgical incision

b) The compact navigation station can be placed close to the operative field and manipulated trough a sterile draping device

c) Only two trackers are necessary to acquire the required landmarks and to provide 3-D control of the correction. These can be inserted within the surgical wound without any secondary incisions

d) The optimized guide accurately controlled the external tibial hinge in all six cases

e) The implant cavity could be milled effectively

f) The distractor used to complete the desired realignment maintained stability of the distraction until final fixation with the PEEK implant

g) The PEEK implant could be fixed to the tibia with excellent stability in a low-profile fashion

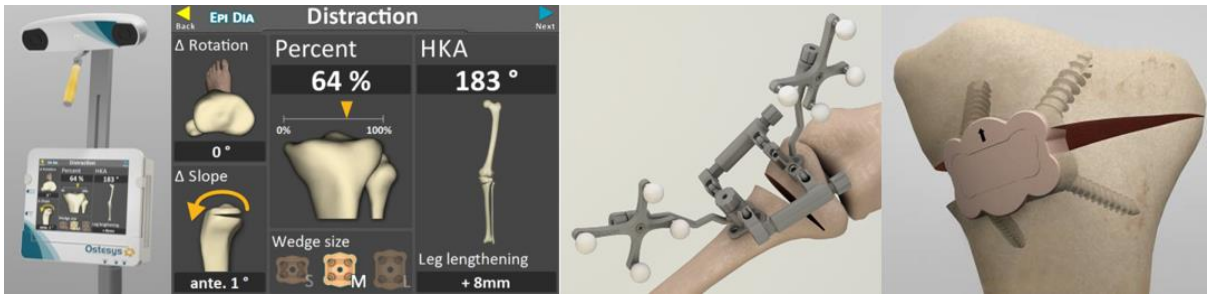

Figure 1: Overview of the different components of the Ostesys HTO solution

DISCUSSION

An HTO is a technically demanding procedure. Long-term survivorship is directly related to the accuracy of the correction. Conventional HTO techniques have many drawbacks. First, preoperative planning is based on two-dimensional x-rays while the correction is performed in a three-dimensional manner with realignment occurring in the coronal plane, tibial slope, and axial rotation. There is no way of confirming or controlling the accuracy of the final correction intraoperatively with techniques that are currently available. This may result in a significant number of failed procedures due to either under- or over-correction.

Computer-assisted protocols have been developed that improve the accuracy to some degree but do not allow control of the location of the external hinge, which is imperative to control the correction in three dimensions [5]. Tibial slope will be altered if the rotation point of the osteotomy is too anterior or too posterior. Because of the integration between the instrumentation, software, and implant, it is possible to plan and execute the osteotomy exactly where it is desired by the surgeon. Other navigation systems also fail to provide

continuous distraction until final fixation, which may lead to the loss of correction. Our technique ensures that stable distraction is present through final fixation, thus avoiding loss of correction.

The solution presented here has the potential to help surgeons perform a medial opening-wedge HTO more safely and accurately. This will likely result in an increase in the number of HTOs performed for both isolated medial compartment osteoarthritis as well as for lower extremity realignment in association with cartilage restorative procedures [6].

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DISCLOSURES

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Eric Stindel, Christian Lefevre, Robert Brophy, Leela Biant, James Stiehl, Matthew Matava are stockholders of OSTESYS

Romain Gerard is a consultant for OSTESYS

Damien Cariou and Pierre Yves Huet are current employees of OSTESYS

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