The Role of Navigation in High Tibial Osteotomy: A Study of 50 Patients

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abstract

From October 1, 2007, to October 10, 2008, we performed 50 navigated high tibial osteotomies (medial opening wedge). The mean age of the patients was 46.58 years (range, 16-70). Twenty-three osteotomies were performed in women and 27 in men. Two patients received osteotomies on both sites. Average malalignment was 6.4° varus (range, 3°-10.8°). Sixteen osteotomies were performed on the right side and 34 on the left side. Detailed preoperative planning was performed using the digital MediCad (Hectec GmbH, Niederviehbach, Germany) program based on the malalignment test. Navigation data were compared using full weight-bearing and intraoperative radiographs. Navigation was shown to be an excellent device for intraoperative control of the amount of correction achieved and offers additional information regarding the lateral plain, ligaments, flexion and extension.

High tibial osteotomies have been used over the past few years to avoid the need for a prosthesis.1-5 Detailed preoperative planning and selection of patients are necessary to ensure success of the operation.6-12 However, even with advanced hardware (plates)13 and advanced operation procedures, failures continue to occur, especially those associated with undercorrection.12,14-16

However, preexisting methods do not consider weight bearing, and final results are only seen at follow-up when full weight-bearing radiographs are obtained.

Navigation, therefore, could become an important device for intraoperative control, and early literature reported encouraging results.17-19 Some surgeons still use a cable or wire as an intraoperative control device to simulate the mechanical axis line and compare the achieved mechanical axis after osteotomy; others use a radiolucent film (raster plate) positioned under the operated leg. The film contains multiple radiopaque lines arranged in 5-× 5-cm squares. The arrangement of lines and squares makes it possible to determine the intraoperative axis of the leg.

Both methods have disadvantages: the cable method is imprecise, and the x-ray exposure used in the film method is high. Navigation may be an alternative, supplying precise data and reducing x-ray exposure.

From October 1, 2007, to October 10, 2008, we performed 50 navigated high tibial osteotomies to evaluate navigation as a device for intraoperative control.

MATERIALS AND METHODS

Preoperative planning included full weight-bearing radiographs and an evaluation via MediCad. The degree of malalignment, mechanical axis deviation, and medial proximal tibia angle, as well as the joint line convergence angle, were evaluated preoperatively. Every patient was grouped in 1 of 4 groups.

In 1979, Fujisawa et al20 published a fundamental paper concerning the best results in high tibial osteotomies. In this retrospective study, the researchers performed an arthroscopic analysis of 54 patients after closing-wedge high tibial osteotomy and concluded that best results were achieved when the mechanical axis line crossed the lateral tibial plateau at 62% of the tibial plateau width. This point was called the Fujisawa point. Years later, Jakob and Murphy...
modified the Fujisawa point, taking arthritis of the knee into account. 21

As did Jakob and Murphy, we evaluated the joint space in the medial and lateral compartments and grouped all patients into four different groups, naming them FUJI 0, FUJI 1, FUJI 2, and FUJI 3 to acknowledge Fujisawa’s initial work. If medial joint space narrowing of one-third of the lateral joint space was evident, the patient was grouped in FUJI 1. Patients in FUJI 0 had no difference between the medial and lateral joint space. Patients with a medial joint space narrowed to two-thirds of the lateral joint space were grouped in FUJI 2, and patients with no joint space were assigned to FUJI 3.

In every deformity correction procedure, the aim was to overcorrect according to which FUJI group the patient was in. For FUJI 1 patients, we measured the degree of malalignment using full weight-bearing radiographs and attempted to overcorrect 2°. In FUJI 2 patients, we overcorrected 4°; in FUJI 3, patients we overcorrected 5° to 6°. No overcorrection was attempted in FUJI 0 patients, in whom there was no difference between medial and lateral compartments.

With the patient in the supine position, a raster plate analysis was performed to measure the medial proximal tibia angle and joint line convergence angle before correction.

The operation was then performed with OrthoPilot (B. Braun Aesculap, Tuttlingen, Germany), an image-free navigation tool that uses active tracking ultrasound. Using navigation, we obtained measurements before and after osteotomy. We evaluated the degree of malalignment for both data groups (navigation and radiographs), including the degree of flexion and extension of the lying leg, degree of maximum extension, degree of maximum varus stress, and degree of maximum valgus stress. After osteotomy and alignment, but before fixation with the Tomofix plate (Synthes, West Chester, Pennsylvania), a second raster plate analysis was done to determine whether the mechanical axis line crossed the predetermined “aim” point on the tibial plateau. A new radiograph was obtained to evaluate the medial proximal tibia angle and the joint line convergence angle again. After 3 months, another full weight-bearing radiograph was obtained. Data listed in the Table were gathered according to the written operation procedure.

RESULTS

The mean age of the patients was 46.58 years (range, 16-70). Twenty-three osteotomies were performed in women and 27 in men. Two patients received osteotomies on both sites. Average malalignment was 6.4° (range, 3°-10.8°). Sixteen osteotomies were performed on the right side and 34 on the left side. Three patients were grouped in FUJI 0, 17 patients in FUJI 1, 29 patients in FUJI 2, and 1 patient in FUJI 3.

Three data groups were compared: the navigation data, the radiologic intraoperative data, and the “mixed” data consisting of data obtained from full weight-bearing radiographs 3 months postoperatively.

Figure 1 compares the delta values for all 3 groups with the planned delta value. Navigation mean differed only 2° from the planned mean.

We also investigated whether data for the adjusted medial proximal tibia angle were equivalent to the mechanical axis. Figure 2 shows the change of medial proximal tibia angle in 50 patients and the mean degree of correction. The mean
The medial proximal tibia angle change was 7.1°. Even when changes of the medial proximal tibia angle and mechanical axis are nearly the same values, they are not identical.

Regarding the navigation data, we showed that the degree of varus in the mechanical axis measured using the navigation was less than the measured varus using preoperative full weight-bearing radiographs (Figure 3). On the other hand, the varus test performed using navigation showed higher varus deformity than the preoperative full weight-bearing radiographs, meaning that the preoperative measured varus lies between the initial navigation axis and the performed varus test.

The preoperative mean joint line convergence angle was 2.78° (range, 0.2°-6.6°) and changed to 1.87° (range, 0.1°-4.7°) postoperatively, which is normal according to Paley (Figure 4), who described parallel joint lines within 2° and a value more than 2° as a possible source of a pathologic mechanical axis deviation.22

Regarding the single FUJI groups, only group FUJI 2 had a pathologic mean joint line convergence angle of 3.63° preoperatively that could not be changed into normal range (2.53°).

Figure 5 outlines the joint laxity changes that occur with osteotomy (measured with navigation from the start of the osteotomy to the finish with fixed bone plate and screws), showing a correlation between increasing laxity and decreasing medial joint space (definition of the FUJI groups 0-3). After osteotomy, joint laxity in the FUJI 0 group approximates normal conditions, except with a smaller range of maximum varus and valgus values.

**CONCLUSION**

Navigation is an excellent device to offer intraoperative and online information about the mechanical axis of the leg, as well as dynamic parameters such as flexion and extension and joint play — range of maximum varus and valgus — during operation. Our study provides information about the changing data of navigation and radiographs, including the medial proximal tibia angle and joint line convergence angle, and the changing joint laxity, and we demonstrated a changing joint play with reduced joint laxity and joint line convergence angle. Measurements of varus deformity measured preoperatively by full weight-bearing radiographs differ from measurements obtained by navigation with the patient in the supine position. A stress test forcing the knee in maximum varus shows a higher value of varus than the preoperative existing varus deformity. Both measurements should be taken into account when comparing preoperative measured data with navigation data until navigated osteotomy is undertaken.

All factors described in Figures 1 through 5 have yet to be quantified and are subject to change depending on load of the operated extremity and on the unpredictable amount of change incurred by corrective osteotomy.

With further analysis of the data, we intend to extract parameters to simulate a full weight-bearing situation intraoperatively using navigation.

**REFERENCES**


