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Original article

Computer-assisted osteotomy for valgus knees: Medium-term results of 29 cases



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ABSTRACT

Introduction: Computer-assisted surgery has been shown to be beneficial for correcting misaligned lower limbs. The purpose of this study was to analyze the medium-term results of computer-assisted osteotomy for 29 valgus knees. The hypothesis was that computer navigation would allow a valgus deformity to be corrected with similar precision as varus deformity.

Material and methods: The series consisted of 27 patients (29 knees); there were 7 men and 20 women with ages ranging from 15 to 63 years (mean: 42.4 ± 14.3 years). Twenty-four varus osteotomies of the femur (14 medial closing and 10 lateral opening) and five double osteotomies (proximal tibia and distal femur) were performed. The pre-operative functional status was evaluated with the Lysholm-Tegner score. The mean score was 64 ± 20.5 points (range: 18–100). According to Ahlbäck's modified classification for knee osteoarthritis, 12 patients were at stage 1, nine were at stage 2, five at stage 3 and one at stage 4. Two of the knees had no radiological signs of osteoarthritis but had a particularly unsightly deformity; one of these was secondary to high tibial valgus osteotomy. The mean pre-operative hip-knee-angle (HKA) angle was $189.3 \pm 3.9^\circ$; the mean mechanical medial distal femoral angle (mMDFA) was $97.2 \pm 2.6^\circ$ and mechanical medial proximal tibial angle (mMPTA) was $90.1 \pm 2.8^\circ$. The goal was to achieve an HKA angle of $179 \pm 2^\circ$ and mMPTA of $90 \pm 2^\circ$ to avoid an oblique joint line. Functional outcomes were evaluated with the Lysholm-Tegner, KOOS and IKS scores.

Results: No complications other than a transient paralysis of the common fibular nerve were observed. Twenty-three patients (25 knees) were reviewed at a mean follow-up of 50.9 ± 38.8 months (range: 6–144). The mean Lysholm-Tegner score was 92.9 ± 4 points (86–100), the mean KOOS was 89.7 ± 9.3 (range: 68–100), the mean IKS “knee” score was 88.7 ± 11.4 points (range: 60–100) and the “function” score was 90.6 ± 13.3 points (range: 55–100). Twenty-two patients were satisfied or very satisfied. The mean HKA angle was $180.1 \pm 1.9^\circ$, the mean mMDFA $90.7 \pm 2.5^\circ$ and the mean mMPTA $89.1 \pm 1.9^\circ$. The pre-operative goal was achieved in 86.2% of cases (25/29) for the HKA angle and 100% of cases of the mMPTA angle. At the follow-up, none of the knees had been revised with a prosthesis.

Conclusion: Computer-assisted osteotomy for cases of osteoarthritis secondary to valgus knee leads to excellent medium-term results. Navigation provides reliable and accurate deformity correction.

Level of evidence: IV. Retrospective study.

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1. Introduction

Osteotomy at the knee was described more than 50 years ago as a treatment for frontal plane misalignment [1–3] and certain inflammatory conditions with or without lower limb deformity [4]. Osteotomy for valgus deformity is much less common than for varus deformity, as evidenced from the lesser number of published studies and cases [5–10]. In varus knee, it is commonly accepted

that 3–6 degrees of hyper-correction extends the duration of the beneficial effects of the osteotomy [11–15]. In previous studies, our group has shown that computer-assisted surgical navigation will lead to a more accurate correction [16–19]. It is logical to think that the same can be achieved in valgus knees. However, the pre-operative goal or methods to achieve this goal have not been well defined in published studies. We have been using computer-assisted navigation during knee osteotomy procedures for varus deformity in March 2001 and for valgus deformity in September 2001. The primary objective of this study was to evaluate the reliability of computer-assisted navigation in achieving the correction set out before the surgery. The secondary objective of this study was

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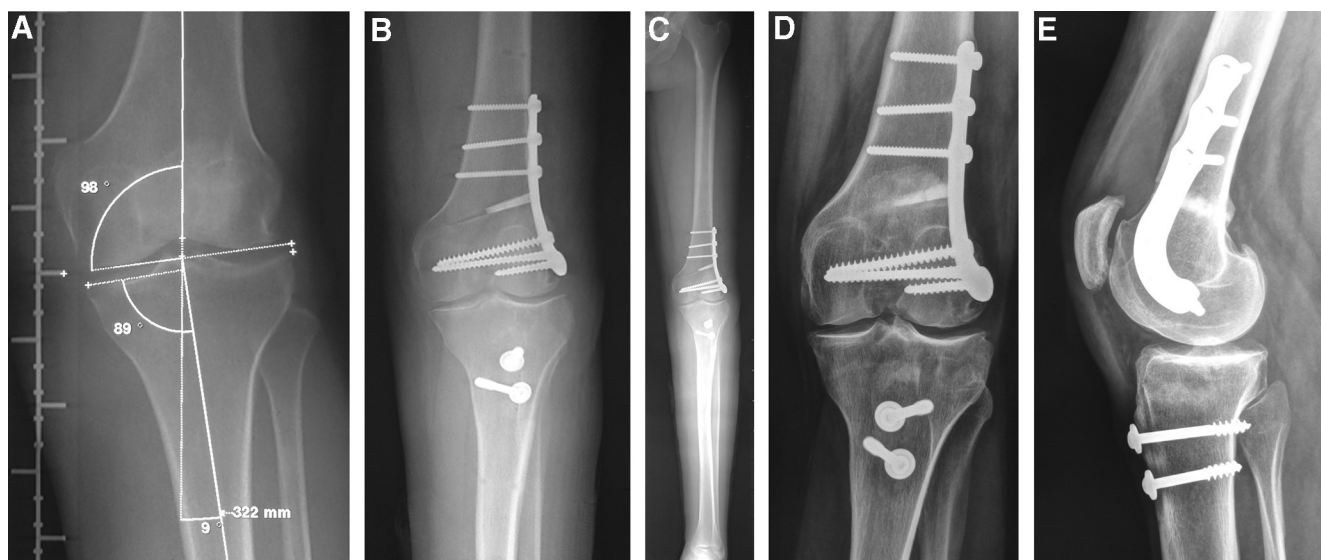


Fig. 1. A. Stage 1 lateral compartment osteoarthritis of the knee associated with patellofemoral osteoarthritis. HKA angle of 189° , mechanical medial distal femoral angle of 98° and mechanical medial proximal tibial angle of 89° . B. Computer-assisted lateral opening femoral varus osteotomy with a tricalcium phosphate wedge and OTIS-F® plate, along with tibial tubercle medialization and iliotibial band piecrust lengthening. C. Post-operative long-leg standing radiograph showing valgus correction. D and E. X-rays one year post-operative; Lysholm-Tegner score of 90.

to evaluate clinical outcomes with an average follow-up of at least four years. Our hypothesis was that computer navigation would allow a valgus deformity to be corrected with similar precision as a varus deformity.

2. Material and methods

2.1. Patient series

Between September 2001 and March 2013, 29 computer-assisted osteotomy procedures for valgus knee were performed in 27 patients (2 bilateral cases). There were 20 women and 7 men with a mean age of 42.4 ± 14.3 (range: 15–63). The right knee was operated in 18 cases and the left in 11 cases. The mean body mass index (BMI) was $26.7 \pm 5 \text{ kg/m}^2$ with a mean height of 170 cm and mean weight of 77.3 kg. Twenty-seven of the knees had lateral compartment knee osteoarthritis, with three of these also having patellar instability. Based on the modified Ahlbäck's classification [17], 12 patients were at stage 1, nine were at stage 2, five at stage 3 and one at stage 4. One patient had no signs of osteoarthritis but instead had a particularly unsightly deformity. Another patient had iatrogenic painful valgus knee after high tibial osteotomy.

The mean pre-operative HKA angle was $189.3 \pm 3.9^\circ$ (range: $181\text{--}198^\circ$); the mean mechanical medial distal femoral angle (mMDFA) was $97.2 \pm 2.6^\circ$ (range: $93\text{--}105^\circ$) and the mean mechanical medial proximal tibial angle (mMPTA) was $90.1 \pm 2.8^\circ$ (range: $86\text{--}95^\circ$).

The pre-operative Lysholm-Tegner score [20] was 64 ± 20.5 points (range: 18–100), the mean IKS [21] “knee” score was 55.5 ± 19.2 points (range: 30–100) and the “function” score was 61.8 ± 29 points (range: 0–100).

2.2. Surgical technique

The main goal was to achieve a $179 \pm 2^\circ$ HKA angle and reduce the mMDFA. The secondary goal was to avoid a valgus mMPTA, which led us to perform five double osteotomies.

All of the procedures were carried out using the Orthopilot™ (B. Braun-Aesculap, Tuttlingen, Germany) navigation system; the

technique used was very similar to the one used in varus knees [16–19]. After intra-operative acquisition of the mechanical axis of the lower limb, the appropriate femoral varus osteotomy was carried out: medial closing in 14 cases and lateral opening in 10 cases. In some cases of excessively tight fascia lata where the required lateral opening osteotomy exceeded 6 to 8° , piecrust lengthening was performed on the iliotibial band (ITB); this contributes to easier recovery of knee flexion (Fig. 1). Medial closing osteotomies were performed in our earliest cases and were secured with an AO T-shaped plate (Synthes, Étupes, France). Lateral opening osteotomy was performed in our later cases; the opening was filled with Biosorb® wedges (SBM, Lourdes, France) and secured with an AO T-shaped plate or an OTIS-F® locking plate (SBM, Lourdes, France). A double varus osteotomy of the femur and tibia due to valgus mMDFA and mMPTA was performed in five cases to avoid an oblique joint line (Fig. 2). In these five cases, a medial closing-wedge osteotomy of the tibia was performed first with an OTIS locking plate and then a lateral opening-wedge varus osteotomy of the femur was carried out. Medialization of the tibial tubercle was performed in three cases with associated patellar instability.

3. Assessment methods

All of the patients underwent a standing A-P long-leg radiograph at the third post-operative month according to Ramadier et al. protocol [22]. The mMDFA was defined as the angle between a line from the center of the femoral head to the middle of the intercondylar notch and a line tangent to the most distal part of the femoral condyles without taking the cartilage into account. The mMPTA was defined as the angle between a line from the middle of the intercondylar eminence to the middle of the talar dome and a line tangent to the bone landmarks on both tibial plateaus without taking the cartilage into account. Medial angles were measured at the femur and tibia.

Functional outcomes were evaluated through the Lysholm-Tegner, KOOS [23] and IKS scores at the last follow-up. Patients were either reviewed by an independent observer (12 cases) or through a telephone questionnaire (11 cases).

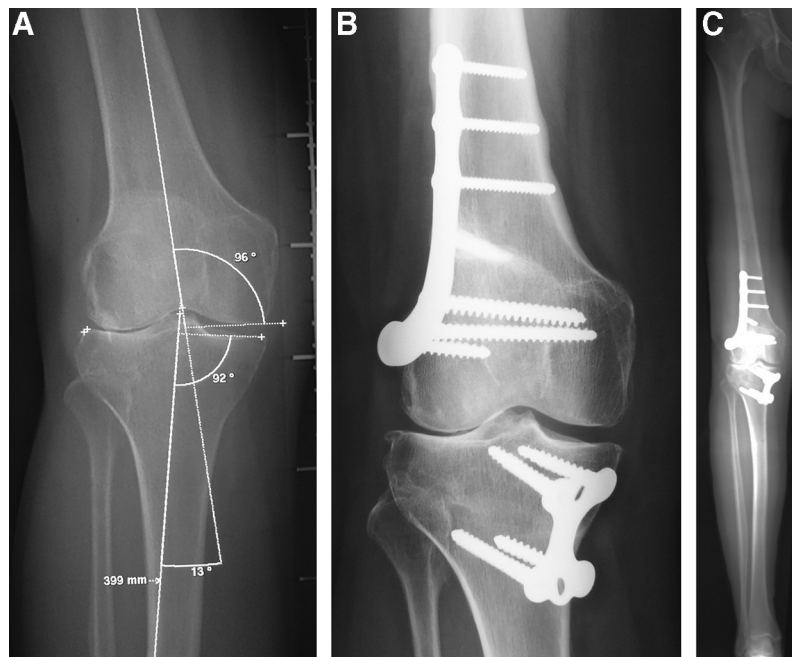


Fig. 2. A. Stage 2 lateral knee osteoarthritis with HKA of 193° , mMDFA of 96° and mMPTA of 92° . B. Computer-assisted double-level osteotomy (medial closing-wedge at tibia and lateral opening-wedge at femur) secured with tricalcium phosphate wedge and OTIS femoral and tibial plate (X-rays at 12 months post-operative). C. Long-leg standing radiographs at 3 months post-operative of the same patients as Fig. 2A and B showing complete valgus correction.

4. Results

4.1. Radiological results

All of the osteotomies had healed within 75 days (range: 60–75). The time to union was the same no matter which type of osteotomy was performed (closing, opening, double); all patients were allowed full weight bearing with one crutch at the 75th post-operative day.

The mean HKA angle was $180.1 \pm 1.9^\circ$ (range: $176\text{--}185^\circ$), the mean mMDFA was $90.7 \pm 2.5^\circ$ (range: $86\text{--}95^\circ$) and the mean mMPTA was $89.1 \pm 1.9^\circ$ (range: $86\text{--}92^\circ$). The pre-operative goal was achieved in 86.2% of cases (25/29) for the HKA angle and 100% of cases for the mMPTA.

4.2. Clinical results

Twenty-three patients (25 knees) were reviewed. The mean follow-up was 50.9 ± 38.8 months (range: 6–144) with 85.1% of patients having been reviewed. The mean Lysholm-Tegner score was 92.9 ± 4 points (range: 86–100), the mean KOOS was 89.7 ± 9.3 (range: 68–100), the mean IKS “knee” score was 88.7 ± 11.4 points (range: 60–100) and the “function” score was 90.6 ± 13.3 points (range: 55–100). Twenty-two patients were satisfied or very satisfied with the outcome; one patient was dissatisfied. None of the patients required surgical revision with a total knee arthroplasty. There was one case of transient paralysis of the common fibular nerve without sequelae.

5. Discussion

Few studies have reported outcomes after osteotomy for valgus knee, likely because this procedure is rarely done. A 2013 meta-analysis found only 27 published studies over a 50-year period, with 7 to 60 cases per study [24]. Most studies report good clinical outcomes after a follow-up of 10 years and satisfaction rates ranging from 64 to 90%. Paradoxically, there is no consensus about the

correction need to obtain a long-lasting result. Some authors suggest under-correcting the joint (0 to 6° for Zarrouk et al. [25]), while others suggest neutral correction [26] or slight over-correction [6]. However, this planned correction is rarely attained and the range is widespread [5–10,25,26]. In the Zarrouk et al. study [25], 12 of the 22 knees achieved the planned correction, despite a fairly large range of 6° . In the Marin Morales et al. study [6], either neutral correction or 1 to 4° varus was planned. In 19 operated patients, the residual valgus was 1° on average, but the final correction ranged from 10° varus valgus!

We started using computer-assisted surgical navigation in 2001 to help us achieve our pre-operative goal more easily. In varus knees, this goal was obtained in 96% of cases with a high tibial osteotomy [16] and 92.7% of cases with double osteotomy [18]. In the current study, the goal of $179 \pm 2^\circ$ is achieved in 86.2% of cases, which is highly satisfactory but not to the same extent as with varus knees. In a few cases, a difference of more than 3° was found between pre-operative goniometer measurements and the computer navigation measurement. In every case, we chose to use the computer-based information because we felt the risk of error was greater for a long-leg standing radiograph (flexion deformity, recurvatum, limb adduction, etc.) than an intra-operative acquisition of anatomical landmarks used to determine the HKA angle. Be that as it may, since we currently do not have better performing and validated tools to measure alignment (2D CT scan, EOS system), we had no choice but to use standard radiographs to carry out these pre- and post-operative measurements and validate the technique, even if a certain amount of uncertainty persists.

In the current study, 14 medial closing femoral osteotomies, 10 lateral opening osteotomies and 5 double osteotomies (medial closing tibial and lateral opening femur) were performed. The closing femoral osteotomy is difficult to carry out. It is not easy to remove a bone wedge corresponding to the planned correction; once the osteotomy has been made, the osteotomy site's stability is disrupted, which requires certain technique tricks to check the mechanical axis of the lower limb with a computer; and finally, if an overly large bone wedge is removed, bone must be added, which

alters the stability of the fixation. As with high tibial osteotomy, we believe it is easier to navigate an opening-wedge femoral osteotomy than a closing-wedge one to the point where we use trial wedges in 1-mm increments, wedge-shaped bone substitutes and more recently a sufficiently stiff locking plate. However, when more than 6 to 8° varus correction is needed and the fascia lata is excessively tight, piecrust lengthening of the iliotibial band may be required to reduce tension on this structure and allow easier recovery of knee flexion. A double osteotomy was performed in five cases to avoid an oblique joint line [12,27]. In these cases, the valgus often exceeded 10° and spanned both the tibia (mMPTA >92°) and femur. We did a proximal closing-wedge tibial osteotomy first and then used a distal opening-wedge femoral osteotomy to adjust the alignment until the planned correction is achieved.

The medium-term clinical outcomes are satisfactory, namely the Lysholm-Tegner score and KOOS, which have better discriminatory power than the IKS score for evaluating the outcomes of an osteotomy. Over the long-term, the reported 10-year survival ranges from 45 to 90% [24]. In the Sternheim et al. study [28], the Kaplan-Meier survival curve shows 89.9% survival at 10 years, 78.9% at 15 years and 21.5% at 20 years.

6. Conclusion

Varus osteotomy procedures for valgus knees can benefit from computer-assisted navigation. This surgical aid makes it easier to attain the correction planned pre-operatively. The medium-term functional outcomes are highly satisfactory and support having an HKA angle of $179 \pm 2^\circ$ HKA as an objective. A long-term study is needed to determine if the quality of life improvements are maintained over time with this amount of correction.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article. D.S. receives royalties from B. Braun-Aesculap.

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