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Computer-Assisted Navigation in Total Knee Arthroplasty without Femoral Hardware Removal

Počítačem navigovaná artroplastika kolenního kloubu s ponecháním osteosyntetického materiálu ve femuru

D. HERNANDEZ-VAQUERO, A. SUAREZ-VAZQUEZ, S. IGLESIAS-FERNANDEZ

Department of Orthopaedic Surgery. School of Medicine, University of Oviedo and Hospital St Agustin. Aviles, Asturias, Spain

ABSTRACT

PURPOSE OF THE STUDY

The use of navigation applied to total knee arthroplasty in knees with femoral hardware retained has not been studied.

MATERIAL AND METHODS

We use navigation in six patients to implant a total knee arthroplasty while retaining the femoral hardware. The retained materials were screws in two cases, diaphyseal plates in another two, intramedullary nails in one and supracondylar tube/plate in another one. Preoperative knee scores were within the 46-66 range, whereas the functional scores were within 40-68. The coronal deformity varied between 30° varus and 5° valgus.

RESULTS

The final femoral mechanical axis was between 2° valgus and 3° varus; the axis of the limb was between 4° valgus and 3° varus. Knee scores improved in all cases, with scores between 75 and 90 points ($p = 0.028$); functional scores were between 64 and 90 points ($p = 0.043$).The final range of mobility was within the 70°-110° range, with a slight improvement over the preoperative status ($p = 0.042$). No complications have arisen throughout the follow-up (mean 16 months).

CONCLUSIONS

The use of navigation constitutes a good option in the treatment with total arthroplasties for patients with femoral hardware retained.

Key words: total knee arthroplasty, navigation, computer-assisted surgery, femoral hardware, femoral deformity.

INTRODUCTION

The good evolution of total knee arthroplasty (TKA) depends on proper axial alignment, soft tissue balancing, stabilizing the prosthetic joint both in flexion and extension and restoring the level of the articular line to its original site (3). Failure to obtain proper axial alignment may lead to premature loosening or decreased survival of the arthroplasty.

Conventional instrumentation relies on intramedullary femoral instruments and either intra- or extramedullary tibial instruments to obtain proper axial alignment; however, intramedullary instruments cannot be used in patients with substantial residual bony deformity associated with previous trauma or in the presence of retained hardware. Extracting this material is often complex and a source of problems. Locating the material through radioscopy, the age of the osteosynthesis, the lack of extraction materials, the existence of previous scars which may difficult the access and the bone weakness such an extraction provokes, all increase complications and add technical difficulties which would require a previous intervention or an extended period of time in the operating room when implanting the TKA.

Computer-assisted navigation allows for the placement of an arthroplasty without needing to invade the intramedullary femoral canal. The implant can be placed with a customized, not-previously-defined alignment. A wide range of literature on the usefulness of surgical navigation in TKA already exists, and there are also numerous comparative studies on the radiographic results obtained with and without navigation (10, 14). However, no publications report these results when surgical navigation is applied to knees with retained femoral hardware.

MATERIAL AND METHODS

Six patients with knee arthrosis underwent surgery with navigation to implant a total knee arthroplasty while retaining the femoral hardware. The age of the patients was between 56 and 73 years; four were men and two, women. In all cases, primary operation had been performed due to traumatic femur fractures between the years 1987 and 2002. Weight-bearing anteroposterior knee radiographs and knee lateral radiographs were obtained in all patients pre- and postoperatively; a CT surview (hip to ankle) was carried out as well and repeated during the immediate postoperative period in order to find the mechanical axis of the limb.

The retained materials were screws in two cases, diaphyseal plates in another two, Ender nails in one, and supracondylar Free Lock tube/plate (Zimmer Inc, Warsaw) in another one. Preoperative knee scores were within the 46-66 range, whereas the functional scores were within 40-68. The coronal deformity varied between 30º varus and 5° valgus. Two cases featured flexion deformities of 5º and 10º, respectively (cases 4 and 5). One patient did not exhibit any preoperative deformity (Tab. 1).

A wireless nonimage-based navigation-assisted system (Stryker-Leibinger, Freiburg, Germany) which constructed a bone model based on the registered femoral head center, the points on the distal femur and proximal tibia, and the malleoli, was used in all cases. Registration was performed in the standard fashion after insertion of three pins in the distal femur and one screw in the proximal tibia where trackers are affixed. The navigational tools rely on the communication between the light-emitting diodes on the trackers and the infrared camera that locates the tracker position in space. The positional information of the trackers, the attached bone, and the instruments are analyzed by the computer, which determines the real-time position of the leg within a 3-dimensional coordinate system. The mechanical axis and the severity of the lower limb deformity were obtained by the standard registration process. Conventional cutting blocks were navigated into position to perform the appropriate bone cuts. The degree of soft tissue release and medial and lateral gap imbalance was quantified by the computer. Medial release for varus knees and lateral release for valgus knees were performed to achieve rectangular balanced gaps and a fully restored mechanical axis. All patients underwent TKA using a cemented, posterior cruciate substituting design (Triathlon, Stryker) and all patients had resurfacing of the patella. In two cases, patellar release was performed. The average length of the operation was 75 minutes (range, 65-95).

Non-parametric statistical hypothesis test (Wilcoxon signed-rank test) was used. Analyses were performed using SPSS version 15.0 (SPSS Inc., Chicago, IL).

RESULTS

Mean follow-up was 16 months (range, 12-26). In all cases a conventional arthroplasty could be implanted without extracting any retained material component (Fig. 1-3). No intraoperative complications arose. The final femoral mechanical axis was between 2º valgus and 3º varus; the axis of the limb was between 4º valgus and 3º varus (Tab. 1). Knee scores improved in all cases, with scores between 75 and 90 points ($p = 0.028$); functional scores were between 64 and 90 points ($p = 0.043$). The average femoral sagittal was 2º of femoral flexion.

The final range of mobility (ROM) was within the 70º-110º range, with a slight improvement over the preoperative status (15º); nevertheless, the difference was statistically significant ($p = 0.042$). No complications have arisen throughout the follow-up. Nowadays, all the patients walk without using walking sticks and none of them require analgesic medication.

Tab. 1. Preoperative and postoperative data

Case	Hardware	Preoperative				Postoperative				
		Mechanical femoral axis	Knee score	Function score	ROM	Mechanical femoral axis	Knee score	Function score	ROM	Limb alignment
1	Supracondylar Free Lock	15º varus	46	40	10-75	2º valgus	76	88	10-95	2º valgus
2	Diaphyseal plate	10º valgus	66	68	5-95	2º valgus	90	90	0-95	4º valgus
3	Ender nails	0º	62	58	15-85	2º varus	76	64	10-80	3º valgus
4	Distal metaphyseal screw	20º varus	53	46	15-90	3º varus	75	69	5-90	3º varus
5	Distal metaphyseal screw	10º varus	57	78	5-90	2º varus	88	78	0-110	2º varus
6	Metaphyseal plate	5º valgus	46	67	10-85	2º valgus	82	84	0-100	3º valgus

ROM: Range of mobility

Fig. 1. Case 4. Femoral screw and varus deformity due to a femoral fracture suffered 22 years ago. Total knee arthroplasty with retained hardware.

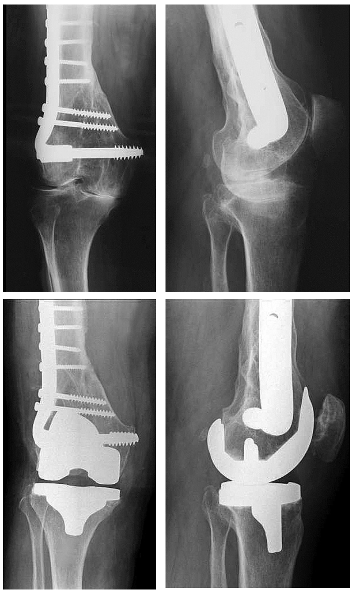

Fig. 2. Case 1. Free Lock retained in total knee arthroplasty.

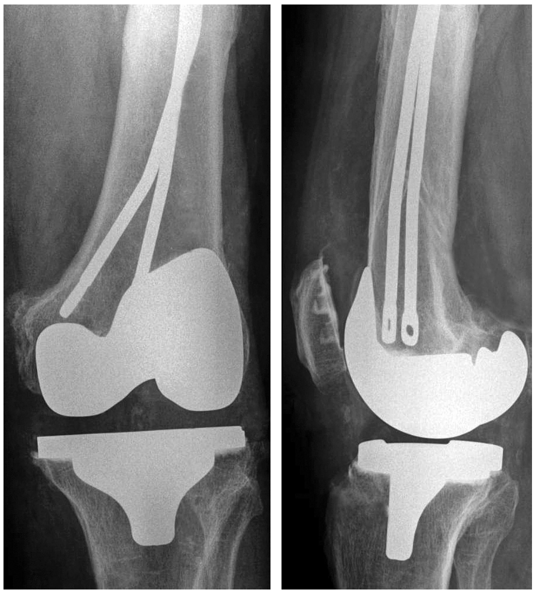

Fig. 3. Case 3. Total knee arthroplasty with Ender nails for femoral diaphyseal fracture suffered 18 years ago.

DISCUSSION

A proper alignment in TKA has been defined as within ±3° of the mechanical axis or between 0° and 4° of valgus. Implanting a TKA to treat arthrosis coupled with a periarticular deformity poses a challenge for the surgeon, because it is very complex to achieve an exact alignment when performing surgery on highly altered structures. Attaining a correct alignment becomes even more difficult when extra-articular deformities exist; in some series, the ideal alignment does not reach 40%, (9, 13). In addition, these deformities (which are almost always traumatic) are associated to the obliteration of the medullar canal and sometimes also to retained material. In such scenarios, intramedullary femoral instrumentation cannot be used, complicating even further the surgical procedure. The presence of material demands performing two incisions creates technical difficulties and puts the patient at risk of suffering a refracture.

Navigation may improve component placement in TKA and, more importantly, it can better reproduce the axis of the limb than when using the standard surgical approach. It offers surgeons an opportunity to improve their judgment with regard to the accuracy with which they perform and evaluate each step of the TKA procedure; besides, navigation can generate precise, accurate, and reproducible alignment measurements. Navigation does not require inserting intramedullary femoral guides and reconstructs the mechanical axis of the limb, allowing for a customized surgery and the monitoring of surgical gestures, which may be checked and modified while the operation takes place. This technology can function as an effective tool for assessing pre- and postoperative limb alignment and for relating intraoperative alignment measurements to clinical and functional outcomes (2). In addition, the absence of this intramedullary time may reduce systemic emboli (7) and blood loss (5), and decrease the potential for fat emboli.

The literature shows navigation-assisted TKA series implanted in both intra (4) and extra-articular deformities. Previous case reports of computer-navigated TKA in knee arthrosis with extra-articular deformities have reported good functional and alignment outcomes. If we stick to femoral deformities, Botros et al. (1) refers 9 cases with a mean previous deformity of 5.1º varus which improves and evolves to a 1.3º valgus with a significant improvement in knee score, functional score and ROM. The longest series published is that of Mullaji and Shetty (11), with 22 cases of femoral deformity, although only 4 cases are secondary to fractures, in which a limb alignment restoration was achieved, with improvements in both the knee and functional scales. Kang et al. (6) presents 4 cases in which the MIS technique has been used.

Our study is the first to specifically present the usefulness of navigation when retained femoral hardware is present. Studies on navigation in deformities by Klein et al. (8) and Fehring et al. (3) mention this eventuality. The former presents 4 cases of retained material out of 5 cases showing deformities, whereas the latter presents 3 cases out of the 10 studied patients. The outcomes achieved with our patients prove that it is possible to adequately place a knee arthroplasty without first extracting the osteosynthesis material. Even though the initial conditions of the limbs showed alterations of the femoral axis between 20º varus and 10º valgus, a correct alignment was achieved in all cases. The same happened with the mechanical axis of the limb. Preoperative knee score increased a mean of 55 points up to 81.2, and the functional score increased from 59.5 to 78.8, showing significant differences. Knee mobility increased only a mean of 15º, which was expected, since the starting conditions were very poor. These data are in keeping with other studies reporting TKA outcomes for patients exhibiting a reduced preoperative mobility (12).

Some limitations of this study which should be mentioned are that it is not prospective and that it has no control group. The current study group should have been compared with a control group treated with conventional techniques to clearly demonstrate the advantage of the computer-navigated technique. The series features six cases only. This was because of the rarity of retained hardware in patients with knee arthrosis. In our series of 510 cases of surgical navigation in TKA, only these six cases were found (1.2%); in Mullaji and Shetty's series (11), however, retained femoral material is only present in 2 cases; that is a 0.2% of the total cases in his navigation series. Although the rotational aspect of the TKA has not been part of this study, it was monitored, together with sagittal alignment, through the screens of the navigation system. The required modifications were performed so as to obtain the correct position of the arthroplasty.

The use of navigation constitutes a novelty in the treatment of total arthroplasties for these patients. The presence of long stems in revision surgery of the hip, the difficulties of extracting obsolete and no longer commercialized osteosynthesis materials, the predictable rate of periprosthetic femoral fractures and the greater presence of osteosynthesis in the treatment of femoral fractures, all contribute to heighten the importance and value of assisted navigation to implant a TKA; in some cases it will even become indispensable.

CONCLUSIONS

Material retained at the femoral level should be considered as a well-defined marker for the use of the computer-assisted surgery in total knee arthroplasty.

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Corresponding author:
Prof. Daniel Hernandez-Vaquero
Apartado de Correos 341. 33400, Aviles, Asturias, Spain.
E-mail: dhernandezv@meditex.es