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CLINICAL STUDY

Axial deviation in total knee arthroplasty – is the navigation system necessary?

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Abstract: *Background:* The aims of the total knee arthroplasty are to reduce or completely relieve pain and improve mobility of the affected joint. In the last decade navigation systems based on computer and infrared camera technology are developing quickly as an alternative to conventional surgical navigation techniques.
Methods: We compare post-operative results in 2 groups of patients after total knee arthroplasty. The groups consist of patients operated with the navigation system performing total knee arthroplasty compared with another group patients where we implanted the total knee arthroplasty using mechanical navigation system for bone resection. All patients suffered from gonarthrosis grade III or IV and had pre-operative axial deformity of the mechanical axis in the knee more than 10 degrees. Post-operative follow up X-ray was aimed to establish the mechanical axis of the limb (Mikulicz line). Statistical analysis was directed on testing the difference between two groups using the method of Mann-Whitney non-parametric test.
Results: Using the computerised navigation system we achieved excellent or good result in as much as 94 % patients; whereas using the conventional navigation such results were in 87 %. It was delightful to find that using the computerised navigation system we did not have any dissatisfactory result and the range of axial deformities deviating from the ideal Mikulicz line was significantly reduced.
Conclusion: Results of our study show advantage in using the optoelectronic navigation system in total knee arthroplasty. Computerised navigation system enables exact insertion of knee components which results in longer life-span of the prosthesis *(Tab. 2, Fig. 6, Ref. 19).* Full Text (Free, PDF) *www.bmj.sk.*
Key words: axial deviation, total knee arthroplasty, navigation system.

The total knee arthroplasty numbers are steadily rising. In economically strong countries the ratio of knee arthroplasties to hip replacements is approximately 1:1 with tendency of knee arthroplasties to prevail. This is due to frequent arthrotic changes in knee joints. Arthrosis of knee joint can develop as a result of congenital deformities (varous or valgous axial congenital deviation, Fig. 1), secondary to post-traumatic changes or to rheumatoid arthritis. However the most frequent is primary arthrosis due to wear and tear of the joint cartilage.

The aims of the total knee arthroplasty are to reduce or completely relieve pain and improve mobility of the affected joint. The longest possible life-span of the implant is also of prime importance. Improvements in the design of prosthesis, in the instruments used and also in the surgical technique prolong the life-span of prostheses. At present according to several studies functional life of the knee implant is preserved in 85–95 % of patients 10 years after the arthroplasty (1, 2). In the last decade navigation systems based on computer and infrared camera technology are developing quickly as an alternative to conventional surgical navigation techniques – CAS: Computer Assisted Surgery (Fig. 2). These systems show three-dimensional image of bony structures of femur and tibia and establish their anatomical axis and the mechanical axis of the limb. These data facilitate exact resection of distal femur and proximal tibia in the sagittal and frontal planes and the height of the resection of the bone (3, 4). This level of accuracy is difficult to obtain using conventional navigation systems even with per-operative radiology at hand. Conventional manual instruments with intramedullar or extramedullar navigation technique show 5 to 10 percent less satisfactory results (5). Quality of surgery, above all the optimal correction of deformities, is the most important factor for durability of the prosthesis (6). Optimal axial inset of the prosthesis reduces the tear and wear of the polyethylene inserts prolongs the life-span of the prosthesis (7).

Our work aims to contribute to the solution of a dilemma: is it really necessary to use per-operative navigation system during the total knee arthroplasty?

Patients and methods

Aim of this paper is to compare post-operative results in two groups of patients after total knee arthroplasty. In our orthopaedic hospital we used in period May 2004 and May 2006 the navigation system performing total knee arthroplasty (group A) one-

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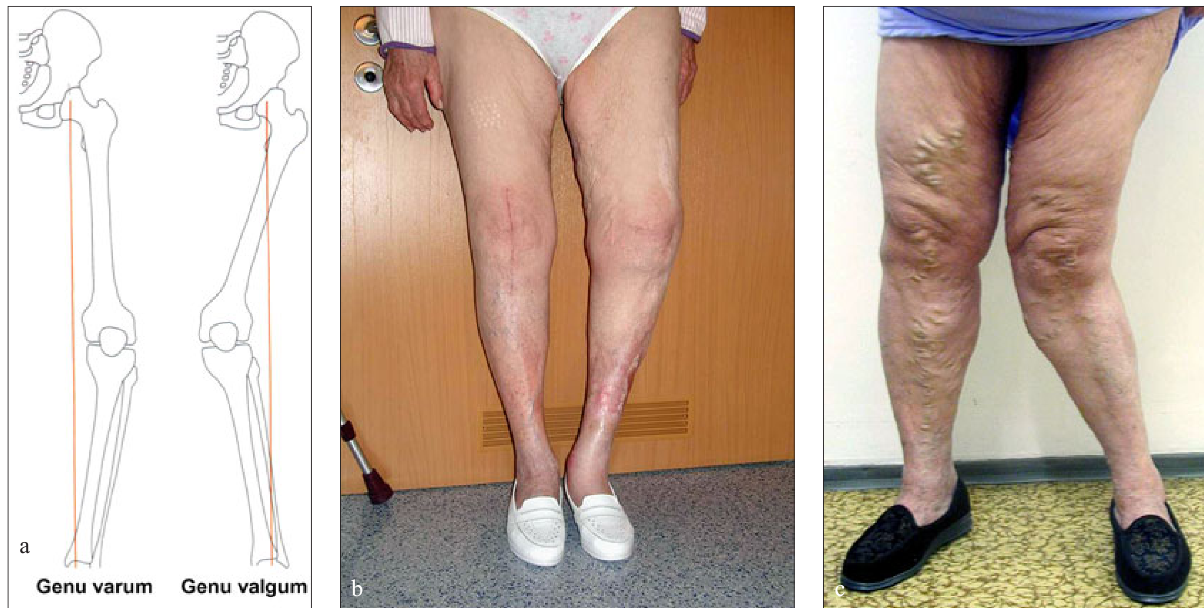

Fig. 1. Schematic draw (Fig. 1a) and photographs of varous (Fig. 1b) and valgous (Fig. 1c) axial deviation of knee.

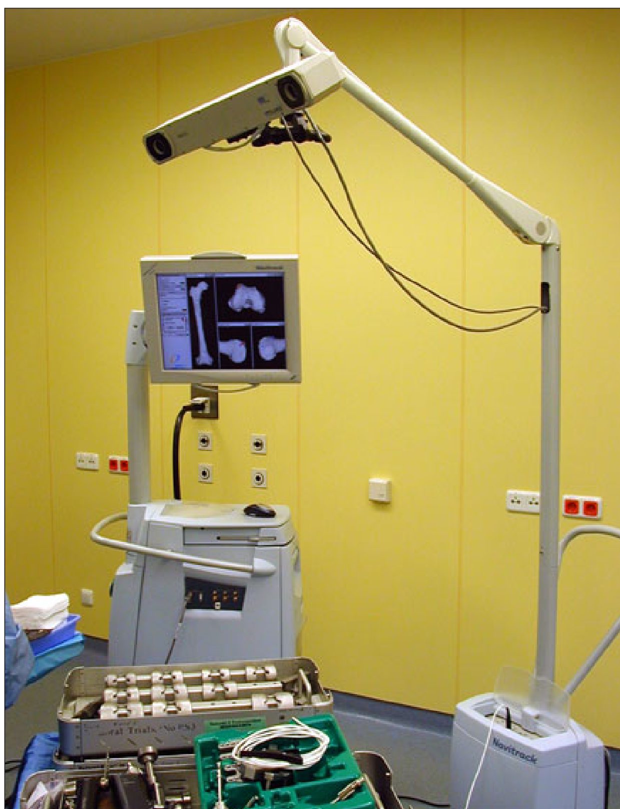

Fig. 2. Navitrack navigation system.

-hundred times. There were 59 women and 41 men; mean age was 62.00±7.63 years. The mean value of pre-operative axial deviation was 14.21±2.47. We compared surgery results with another group of 100 patients where we implanted the total knee arthroplasty performed the conventional way – using mechanical navigation system for bone resection (group B). There were 62 women and 38 men; mean age was 65.79±9.48 years. The mean value of pre-operative axial deviation was 13.77±2.34. Detailed characteristic of both groups are showed in Table 1.

All patients suffered from gonarthrosis grade III or IV and had pre-operative axial deformity of the mechanical axis in the knee more than 10 degrees. We operated 178 of these patients using a mechanical tourniquet on the proximal part of their thigh. We could not use the tourniquet in 22 patients because of their previous thrombosis on the operated leg or because of peripheral vascular disease of their lower leg. We operated 44 patients in the general anaesthesia and 156 in epidural or subarachnoideal block. In all patients in this study we used standard cemented implants without the patella replacement. In operations using mechanical navigation system the system was anchored intra-

Tab. 1. Pre-operation characteristics of both groups of patients.

	Group A (using computerised navigation) n=100	Group B (using conventional navigation) n=100
Age (mean±SD) (p=0.101 NS)	62.00±7.63	65.79±9.48
Men:Women	41:59 (ratio 0.69)	38:62 (ratio 0.61)
Axial deviation (mean±SD) (p=0.008 *)	14.21±2.47	13.77±2.34
% of varous:valgous deviation	59%:41%	59%:41%
% right side:left side	42%:58%	52%:48%

SD – standard deviation, NS – non-significant; * – significant

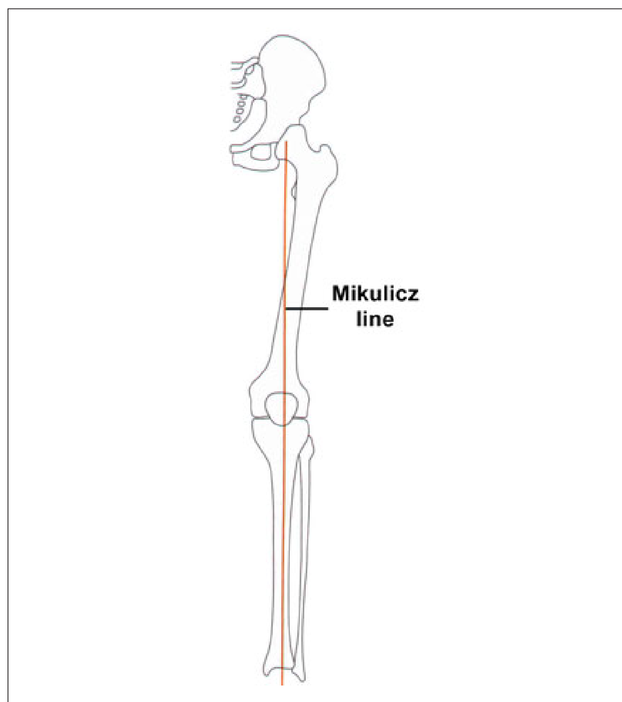

Fig. 3. Mechanical axis of the limb – Mikulicz line.

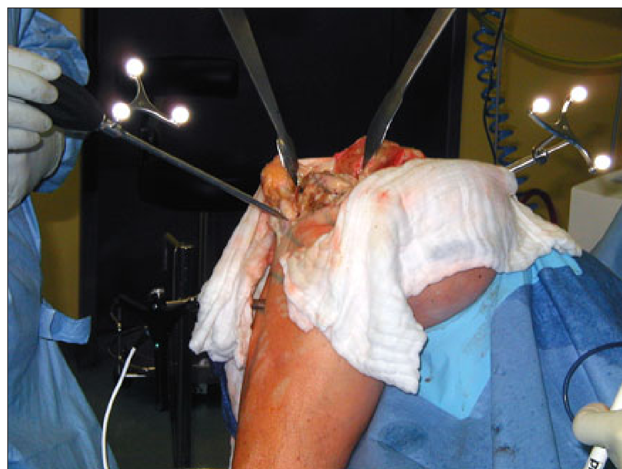

Fig. 4. Mosaic pointer of navigation system.

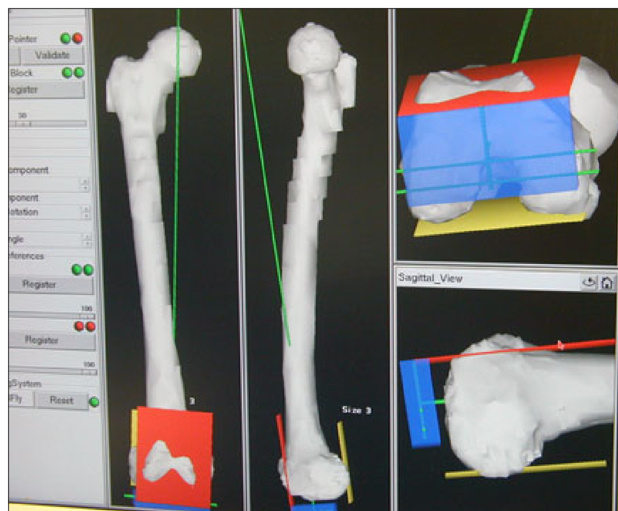

Fig. 5. Three-dimensional model of operated femur.

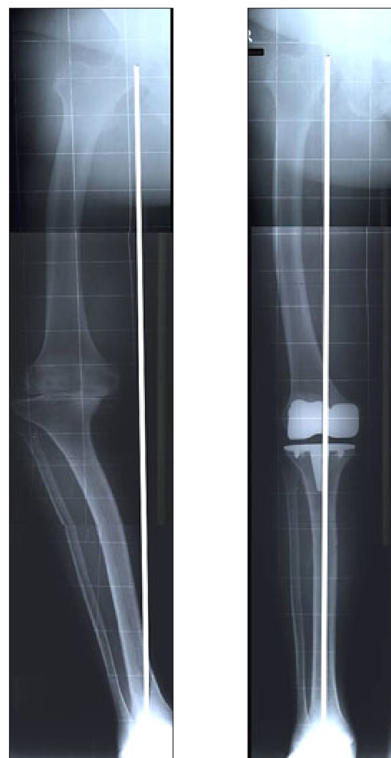

Fig. 6. Pre-operative and post-operative X-ray image – white line is the mechanical axis of the limb (Mikulicz line).

medularly both in femur and tibia. During the study period we were not forced to pause any of the operations owing the technical fault of the navigation system. All operations in this study were performed by 3 experienced surgeons and standard physiotherapy protocol was used across both groups.

In our orthopaedic hospital we use optoelectronic navigation system NAVITRACK that does not require pre-operative computer tomography (CT) examination. This system uses exactly defined reference points that establish centre of the femoral head and of the talocrural joint. These points are important for optimal definition of the mechanical axis of the limb (Mikulicz line) (Fig. 3). At the same time the reference anatomical points are established to enable correct rotational positioning of the implanted components. Using the infrared camera and a locator (mosaic pointer) (Fig. 4) the computer optimises position and size of the prosthesis based on the centre of rotation of the femoral head. After digital processing of the measured points the navigation system displays a three-dimensional model; based on which we establish the resection blocks on the femur and the tibia. The resected surfaces can be shown on the three-dimen-

sional model and if needed they can be corrected (Fig. 5). Correction is usually necessary in case of not using an ideally sharp saw when resecting a sclerotic bone. Before the definitive insertion of the prosthesis we use the computerised model to establish the new mechanical axis of the limb, the size and rotational position of the components of prosthesis and also to show the varous and valgous stability of the knee in flexion and extension.

For the precise function of the navigation system it is crucial to stabilise the reference screws in the bone very well. Especially in ostheoporotic bone it can be difficult to anchor the reference screws well despite the fact they are bicortical.

Post-operative follow up X-ray was aimed to establish the mechanical axis of the limb (Mikulicz line) (Fig. 6). Statistical analysis was performed using statistical software SPSS for Windows version 13.0. Analysis was directed on testing the difference between two groups using the method of Mann-Whitney non-parametric test on the level of significance 95 % ($p<0.05$).

Tab. 2. Post-operative results in both groups of patients.

	Group A (using computerised navigation) n=100	Group B (using conventional navigation) n=100
Axial deviation (mean±SD) (p<0.001*)	1.51±1.34	2.12±1.35
% of patients with excelent results of operation (0–1)	56%	38%
% of patients with good results of operation (2–3)	38%	49%
% of patients with satisfactory results of operation (4–5)	6%	11%
% of paients with dissatisfactory results of operation (>5)	0%	2%

Results

In both groups (group A – using computerised navigation, group B – using conventional navigation) we assessed the post-operatively established mechanical axis of the limb – Mikulicz line. Deviations of 0–1 is classified as excellent; deviations of 2–3 as good; deviations of 4–5 as satisfactory and deviations more than 5 as dissatisfactory. Our results are showed in Table 2. In group A we reached significantly better operation results, as in group B. In group A was the axial deviation from Mikulicz line 1.51±1.34, in group B was the axial deviation from Mikulicz line 2.12±1.35 ($p<0.001$).

In group A we achieved excellent results in 56 % patients compare to 38 % in group B. So called “satisfactory” results were found in group A only in 6 cases (group B 11 cases) and we did not have any dissatisfactory result of axial deviation of more than 5 in group A using computerised navigation system. There were 2 cases with resulting axial deviation of more than 5 using the conventional navigation.

Using the computerised navigation system we achieved excellent or good result in as much as 94 % patients; whereas using the conventional navigation such results were in 87 %. It was delightful to find that using the computerised navigation system we did not have any dissatisfactory result and the range of axial deformities deviating from the ideal Mikulicz line was significantly reduced.

Discussion

Long-term good results of total knee arthroplasty are among other factors subject to correct axial insertion of the prosthetic components (8, 9). Jeffery et al (10) found loosening of the components of knee prostheses only in 3 % of patients with correct mechanical axis on 8 years follow up. In patients with incorrect mechanical axis they reported failure in up to 24 %. Where is the cut off point between correct and incorrect mechanical axis? Rand and Coventry (11) found 10 years stability of the knee prosthesis in as much as 90 % of patients who had mechanical axis of the limb between 0–4 of valgous deviation. Contrary to that valgous deviation over 4 meant life-span of the prosthesis reduced to 71 %. Close relation of durability of the prosthesis to optimal mechanical axis of the limb only highlights the importance of good navigation systems. Multiple studies have shown that using computerised navigation system enables to achieve better results of total knee arthroplasty with resulting mechanical axis deviation of less than 3 (12, 13, 14, 15).

Conclusion

Results of our study show advantage in using the optoelectronic navigation system in total knee arthroplasty. Computerised navigation system enables exact insertion of knee components which results in longer life-span of the prosthesis.

A disadvantage of the computerised optoelectronic system is the expense of having such a system – approximately 100 000 EUR. Also the duration of the surgical procedure is prolonged at the beginning by 20–30 min. The same experiences have Zorman et al (16). After consolidation of the experience this delay is only 10 to 15 min. When using the reference screws in femoral and tibial diaphysis approximately 15 percent of patients complain of pain of variable intensity in the site of their insertion. This pain usually resolves within 3 to 5 weeks. Our experience based on time when we did not have the advantage of computerised navigation is that an experienced surgeon is able to handle well even the most complicated cases using the conventional navigation and radiological guidance. Main indications for use of the computerised navigation system are significant axial deformities in the knee joint or significant post-traumatic anomalies of femur and tibia. From the economical point of view it is optimal if there is an orthopaedic hospital within 100–120 km distance equipped with a computerised navigation system where these complicated cases can be referred.

Ongoing development of navigation systems and their simplification will reduce their present disadvantages. Resulting prolonged durability of prosthetic knee implants after their optimal surgical insertion will mean reduction of costs and significant increase in patients' satisfaction.

In the near future, not only the surgical techniques, but also methods of the cartilage tissue engineering (or their combination) may improve the quality of patient's life with degeneration of articular cartlige (17, 18, 19).

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