Introduction

Following its development period from 1993 to 1997 [12] in joint and spinal surgery, the OrthoPilot system has proved its technical efficiency from 1997 onwards in a cadaver study [9] and in subsequent clinical trials [7]. Moreover, the OrthoPilot navigation system has also shown substantially better results compared with the use of manual instrumentation [2-4, 8, 11]. It was reported in a multicenter study [1] that a statistically significant improvement in the alignment of the knee prosthesis components in respect of the mechanical leg axis and the femoral and tibial individual axes could be achieved with the OrthoPilot system as opposed to the manual technique. It should be noted here that the »learning curve« of all the centers taking part was included in the results. The superiority of the navigated implantation technique became particularly obvious when the five set parameters of $0° \pm 3°$ for the mechanical axis and $90° \pm 2°$ for the individual axes were observed. Such results, which are to be considered very good, were achieved in 49.6% of cases with the navigated technique, whereas the attainment rate with the manual implantation technique was only 30.8%. In a comparative investigation between 100 navigated cases with the Search Evolution knee and the manually instrumented LCS knee system, Konermann and Saur [5] showed even clearer differences in favor of the navigated technique using the same criteria. With the navigation technique they observed very good results in respect of all five axes in 54% of the cases, whereas this was the case in just 15% of the patients treated with manual implantation technique.

In software versions 1.0 to 2.2 the OrthoPilot system simply navigated the tibial resection and the distal femoral resection planes of a total knee arthroplasty. Versions 3.0 and 3.1 included, in addition, the rotational alignment of the femoral component through acquisition of the transepicondylar axis via the medial and lateral femoral epicondyle. The inaccuacies in defining the femoral epicondyles must be taken into account here.

The goal in total knee replacement is not only to create an accurate axis of the leg within $\pm 3°$ of the Mikulicz' line, but also to balance the soft tissues. This is necessary to prevent unequal polyethylene wear and early implant failure as well as to achieve stability of the knee during the whole range of motion.

Exact positioning of the femoral component in relation to the tibial component in both extension and flexion may be facilitated by recording the data of the flexion and extension gaps.

A first step in this direction had already been made with the SurgiGATE system [14]. The Galileo system [12] and the VectorVision system (see chapter 36) also integrate the measurement of extension and flexion gaps. The Stryker Leibinger navigation system [6, 13] uses the distance between femoral epicondyles and the resection on the proximal tibia to arrive at two curves for the medial and lateral side of the knee joint over the entire range of movement. These curves provide information about contractures on the one hand or instability on the other, and in this way make soft tissue management possible. However, inaccuracies exist in the difficulties in exactly determining the femoral epicondyles.

Version 4.0 of the OrthoPilot system uses a special gap spreader to achieve accurate recording of flexion and extension gap data. This allows conclusions to be made about a necessary soft tissue release, and thus soft tissue management as a whole.
Surgical Technique with Version 4.0

There are no differences from the previous software versions 3.0 and 3.1 in respect of the distal femoral entry point, intraoperative kinematic analysis with circumference of the hip to determine the femoral axis which runs through the centre of the femoral head, the definition of the centre of the ankle and knee joints and the acquisition of the knee joint line, the deepest defect point of the dorsal condyles, the anterior cortex on the distal femur and the malleolar triangle. When the leg axis has been established and displayed on screen following kinematic analysis, the first qualitative information about a necessary soft tissue release is provided.

But Version 4.0 goes further than this limited possibility of performing soft tissue release.

In addition, the more modern system employs a universal alignment guide for both tibial head and distal femoral resection. This guide can be adjusted in all three degrees of freedom, allowing the valgus/varus position, slope and resection height to be adjusted. Only the resection blocks for the tibial and femoral sides are different.

The tibial resection block is first fixed into position provisionally on the head of the tibia using the universal alignment guide. Next follows the precise alignment in all planes and final fixation of the block, after which the tibial resection is performed. The tibial resection plane data are subsequently recorded using a tibial template and the accuracy of the resection is checked.

When this has been completed, a femoral plate is placed on the distal femoral condyles, positioned at right angles to the defined femoral axis, and used to record the distal femoral condyle plane, which is important for determining the extent of the distal femoral resection. The potential size of the femoral component, established by the acquisition of the femoral data, is also continuously displayed on the screen.

The next step is to make precise measurements of first the flexion gap and then the extension gap using a special spreader. The measurements are brought together and also indicated on screen. Then the universal alignment guide is provisionally fixed onto the distal femur and aligned in all planes, including the resection height, before being finally fixed into position on the distal femur. The femoral alignment always takes account of the medial and lateral sides simultaneously in their relation to the tibial resec-

The respective value with reference to the resultant height for the tibial polyethylene component is also given. This is followed by distal femoral condyle resection. The data of the distal femoral condyle resection are recorded with the femoral navigation template (Fig. 34-1).

Now the femoral template is laid onto the distal femoral resection and the femoral component is brought into rotational alignment with the tibial resection plane. During this procedure the effects of the rotation of the femoral component on the flexion and extension gaps can be directly observed, as can the effects on the flexion and extension gaps of changing the size of the femoral component. In addition, the system informs the surgeon on screen about the anterioposterior position of the component, to avoid notching of the anterior femoral cortex (Fig. 34-2).

When properly balanced conditions of the medial and lateral side in flexion and extension have been achieved, after the correct size of femoral component has been selected and rotational alignment performed, the locating points for the four-in-one resection template are drilled through the femoral template. Then the remaining femoral bone resection is carried out using the four-in-one cutting block.

In practice, a difference of more than 5–6 mm should not be tolerated between the medial and lateral side of the knee joint when measuring the flexion and extension gaps with the spreader. If the differences between the medial and lateral side are too great, additional soft tissue release on the more contracted side should be performed at this point, after which the flexion and extension gaps should be re-measured. This procedure helps to ensure that no unrealistic values for the femoral component occur during subsequent rotational alignment.

Version 4.0 of the OrthoPilot system also contains a module that, following tibial resection, gap measurement and distal femoral condyle resection, permits the surgeon to simulate the conditions that would exist if potential femoral and tibial components were used.

After all the bone resections have been completed, the trial components are implanted and the final axial conditions achieved are displayed on screen. The bones are prepared for the femoral and tibial anchoring mechanisms and the knee endoprosthesis is implanted, including a patella component if required. After implantation the data for the definitive position of the endoprosthesis components are recorded (Fig. 34-3).