The Journal of Arthroplasty Vol. 22 No. 6 2007

Accuracy of Navigation-Assisted Acetabular Component Positioning Studied by Computed Tomography Measurements

Methods and Results

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Abstract: The postoperative position of the acetabular component is key for the outcome of total hip arthroplasty. Various aids have been developed to support the surgeon during implant placement. In a prospective study involving 4 centers, the computer-recorded cup alignment of 37 hip systems at the end of navigation-assisted surgery was compared with the cup angles measured on postoperative computerized tomograms. This comparison showed an average difference of 3.5° (SD, 4.4°) for inclination and 6.5° (SD, 7.3°) for anteversion angles. The differences in inclination correlated with the thickness of the soft tissue overlying the anterior superior iliac spine (r = 0.44; P = .007), whereas the differences in anteversion showed a correlation with the thickness of the soft tissue overlying the pubic tubercles (r = 0.52; P = .001). In centers experienced in the use of navigational tools, deviations were smaller than in units with little experience in their use. **Key words:** hip arthroplasty, cup anteversion, CT measurements, computer-assisted surgery.

Cup positioning is a key factor for the long-term outcome of total hip arthroplasty (THA) [1-3]. The ultimate position of the cup, particularly its anteversion, determines the frequency of dislocations [1,2,4-6] and the extent of component wear [7].

Aside from primary implant stability, accurate implant positioning is therefore indispensable. The accuracy achieved depends on several factors. These include positioning of the patient [3,4], the surgeon's technique and experience [1], and the type of acetabular component used [3].

The optimal implant position has been the subject of many reports [1,4,5,8,9]. It should, however, be noted in this context that the cup angles go by a variety of names. In this article, the terms defined by Murray [10] in his overview will be used.

Surgeons often have problems with precisely aligning the inclination of the cup and even more so its anteversion intraoperatively [6,11,12], particularly in obese patients and in the lateral

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Submitted June 27, 2005; accepted October 2, 2006.
No benefits or funds were received in support of the study.
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0883-5403/07/1906-0004$32.00/0
doi:10.1016/j.arth.2006.10.001

decubitus position [2,4]. These problems prompted the development of several targeting systems, but even with these, not all of the acetabular components were successfully placed in the desired safety zone [6]. One of the underlying reasons is that these systems use the plane of the operating table as reference without accounting for the actual position of the bony pelvis [2,6,13].

For this reason, computer-assisted systems were developed in the nineties to monitor cup alignment and optimize it. Anthony M. DiGioia, one of the pioneers in this field, published his technique in 1998 [14].

With these computer-assisted techniques, computerized tomograms (CTs) are recorded preoperatively for planning. A model of the pelvis extracted from the CT data assists the surgeon intraoperatively [2]. There are 2 disadvantages to this technique: the need for preoperative CTs and planning, and matching the pelvic model extracted from the CT data with the actual patient position on the operating table intraoperatively [12].

These disadvantages prompted the search for techniques that do not require preoperative imaging but are based on landmarks for orientation rather than a CT-extracted model of the pelvis.

Cunningham's concept of the anterior pelvic plane defined by the 2 anterior superior iliac spines and the pubic tubercles (Fig. 1) [15] was used as reference [2]. These landmarks are carefully located and their position is entered in a computer system with the help of an optical unit based on infrared locators for precisely computing the position of the pelvis. During implantation, the computer provides the surgeon with feedback about the actual position of the implants and instruments relative to the pelvis. With the help of a firmly fixed pelvic locator, any movements of the pelvis are also accounted for. This is why the system is called navigation.

Fig 1. Anterior pelvic plane.

Although navigational tools are becoming more and more precise with improved ease of handling, quality assurance based on postoperative follow-up studies of acetabular components continue to be important.

The purpose of our study was to compare the cup angles recorded intraoperatively at the end of surgery with the angles measured on postoperative CTs to shed light on the precision of the navigation system. The effect of fatty tissue thickness overlying the landmarks was another point of interest.

Materials and Methods

Four centers in Germany and Austria, all of them experienced in THA, participated in our prospective study. Two of these centers had also had substantial exposure to navigation systems for implant placement.

Thirty-seven patients (20 women, 17 men; mean age, 65 years) were prospectively enrolled in the study. The right hip was evaluated in 18 patients and the left hip in 19.

All patients were implanted with a cementless threaded biconical cup of pure titanium with a polyethylene inlay and a cementless tapered straight titanium alloy stem with a ceramic ball head (Plus Orthopedics AG, Rotkreuz, Switzerland).

All THAs were performed with the same navigation system (PiGalileo THR, Plus Orthopedics, Aarau, Switzerland). The position of the implanted acetabular component (especially inclination and anteversion, which corresponds to radiographic anteversion) was recorded at the end of surgery. Only these data were used for further analysis.

When the patients had completed their rehabilitation program, computerized tomography without intravenous contrast media was performed with the approval of the ethics commission to pinpoint the cup alignment relative to the bony pelvic structures. Spiral CTs of the entire bony pelvis were obtained and the data were transferred