

PREOPERATIVE PLANNING USING MEDICAD SOFTWARE (GERMANY)

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Abstract - Preoperative planning is an important step in preparing for total hip arthroplasty. Digital preoperative planning allows the surgeon to select templates and overlay them electronically on the image. This way, the necessary measurements of the dimensions of the implants, the position of the implants, and the restoration of the biomechanics are carried out. Digital templating is becoming the preferred method for preoperative planning in total hip arthroplasty (THA). New technologies reduce inconsistencies and errors can be minimized. Our experience with the MediCAD software has shown that its accuracy is within ± 1 size in 85% of acetabular component placements and 82% of femoral component placements. These results are comparable to those reported in the literature to date.

Keywords: preoperative planning, MediCAD

1 Introduction

Preoperative planning is an important step in preparing for total hip arthroplasty. Digital templating is a preoperative planning procedure that improves the efficiency of the operative intervention¹, improves the precision of the predicted implant size⁶, shortens the operative time⁸, and reduces the frequency of prosthesis loosening⁷. Furthermore, it reduces the incidence of periprosthetic fractures, helps preserve the biomechanics and to equalize limb lengths^{2,5,9,13}. According to Maurice Müller, templating "makes the surgeon think in 3 dimensions, greatly improves the precision of the surgery, shortens the duration of the procedure and significantly reduces the incidence of complications". Moreover, digital preoperative planning allows the surgeon to select templates and overlay them electronically on the image. This way, the necessary measurements of the dimensions of the implants, the position of the implants, and the restoration of the biomechanics are carried out.

2 Materials and methods

Between January 2022 and December 2022, we performed 54 preoperative digital plannings of 45 patients who underwent primary cementless total hip arthroplasty. The male: female ratio was 19:26, mean age of 52 years (range 34 to 65 years). Indications for operative intervention were: OA (65 %), AVN (25 %), DDH (7 %), post-traumatic

osteoarthritis (3 %). Surgeries were performed using a Röttinger approach or modified Hardinge approach. The implants used were stems: LCU and SP-CL; capsules: TOP and Mobile by W. Link (Germany).

We used two-dimensional planning (2D) with the help of specialized medical software from the company Mediacad (Germany). For this purpose, a radiographic examination with a standardized DICOM-format protocol is required. Well-oriented frontal views of the pelvis with the presence of a radio-positive calibration marker are required. The marker is placed near the pubis at the level of the greater trochanter. Placing the marker on the outside of the hip often results in projection errors. The frontal radiologic view of the pelvis covers the wings of the iliac bones, both hip joints, and both femurs to the isthmus.

Standard planning includes several stages that cannot be skipped:

- 1) image calibration;
- 2) determining the center of rotation;
- 3) determining the axis of the femoral canal;
- 4) determination of the tip of trochanter major;
- 5) determining the differences in the lengths;
- 6) graphic the cut along the tight;
- 7) determination of acetabular component (type, size and position);
- 8) determination of the femoral component (type, size and position);
- 9) determination of the head and the neck (type, size and length);
- 10) changing the position of the selected implants and checking the measurements of the limb lengths.

There is also an automatic pre-operative planning option, which makes it easier for the surgeon. It identifies the center of rotation, the axis of the femoral canal and the apex of the greater trochanter. Although it is often necessary to make corrections to the bone landmarks, it still saves time. To have reliable radiograph imaging for our planning we need to identify the bony landmarks. Such landmarks should be anatomical structures that are easy to locate during surgery. For example, landmarks of the femur are the medullary canal, the lesser trochanter, and the greater trochanter. The acetabulum landmarks are the acetabular vault and the lig. transversum.

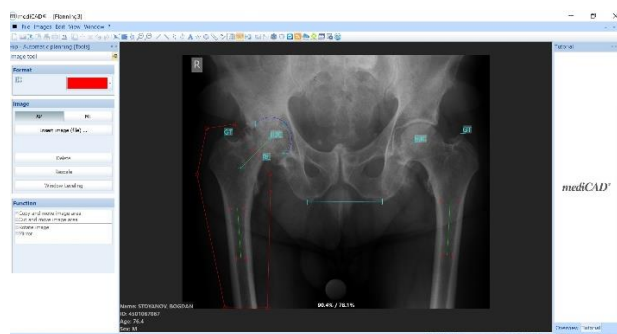


Fig.1 Determining the center of rotation; determining of the femoral canal; determining of the tip of the trochanter major; determining of the differences in the lengths; graphic excision of the femur

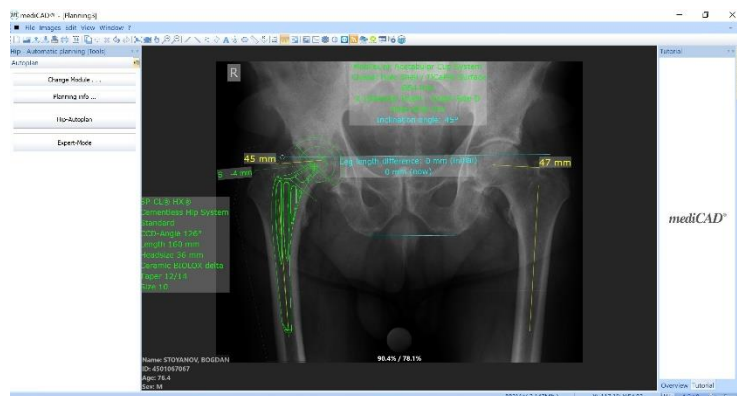


Fig.2 determining of the acetabular component; determining of the femoral component; determining of head and neck

Calibration of the image is performed using a marker of a certain size, which is placed at the level of the greater trochanter. Placing it above or below this level may cause the calibration to be inaccurate and lead to a difference in the planned and final implant. We prefer placing the marker in the area of the pubic bone, as placing it next to the greater trochanter often leads to inaccurate image. Marker placement is not necessary in patients who have undergone unilateral total hip arthroplasty. In such cases, the head on the operated side is used for calibration. This way there is better accuracy in the results.

The center of rotation of the acetabulum can be defined as the point around which all movements of the hip occur. If the acetabulum and the femoral head are not deformed and the acetabulum and the femoral head are spherical, then the center of rotation of the femur and the acetabulum coincide at the same point. The ideal position for the capsule is achieved by placing the inferomedial edge adjacent to the lateral edge of Köhler's tear. For most patients, this will restore the center of rotation and natural biomechanics as much as possible. The longitudinal axis of the femur is determined by a longitudinal line starting from the greater trochanter and bisecting the femoral canal into equal parts. After drawing a horizontal line through the two lesser trochanters and the interischial line, the lengths of the limbs is compared.

Determining the center of rotation

This can be verified by drawing a horizontal and vertical line from Köhler's tear to the center of rotation of the given template. If they coincide with the center of rotation of the unaffected side and there is no difference in the limb lengths, then this is the place to place the acetabular capsule.

Femoral offset

Femoral offset is defined as the perpendicular distance from the longitudinal line drawn along the course of the femoral canal and the center of rotation of the hip joint. Femoral offset has implications for abductor muscle tension, component loading, and acetabular inlay wear. Improper offset recovery leads to premature wear, snapping and

instability of the joint. An excessive increase in offset leads to overloading of the femoral component, causing pain in the abductor muscles and in the area of the greater trochanter.

Acetabular offset

Acetabular offset can be defined as the shortest distance between the acetabular center of rotation and a perpendicular to the Köhler's tear. Acetabular offset is important for abductor muscle tension and proper weight distribution. Decreasing acetabular offset through medialization leads to instability of the joint, and increasing it leads to overload the capsule and premature wear.

Limb length

Limb length is measured by a horizontal line connecting the two ischial tuberosities and the distance to the two lesser trochanters. After determining the anatomical markers, the software automatically calculates the differences in the limb lengths to the nearest millimeter. An error can be made only if there is severe deformity, anatomical deviation or poor image quality.

Positioning of the implants

Planning can be easily done if the anatomy of the joint is preserved. But in case of severe deformity, it is easier to use the healthy side for templating and use the results mirrored.

Same as the surgical technique, templating begins with the positioning of the acetabular component. It is placed in a 45° incline. Under ideal conditions, the capsule should be covered by the bone as much as possible. Determining its size takes place with minimal removal of subchondral bone. The next step is positioning of the femoral component. It must fit and fill the femoral canal. The limb lengths should equalize. Offset and center of rotation can be restored by: 1) medialization or lateralization using a standard or lateralized stem; 2) use of a stem with a different cervical-diaphyseal angle - 126° - 130° - 135° ; 3) using a different neck size- S, M, L, XL.

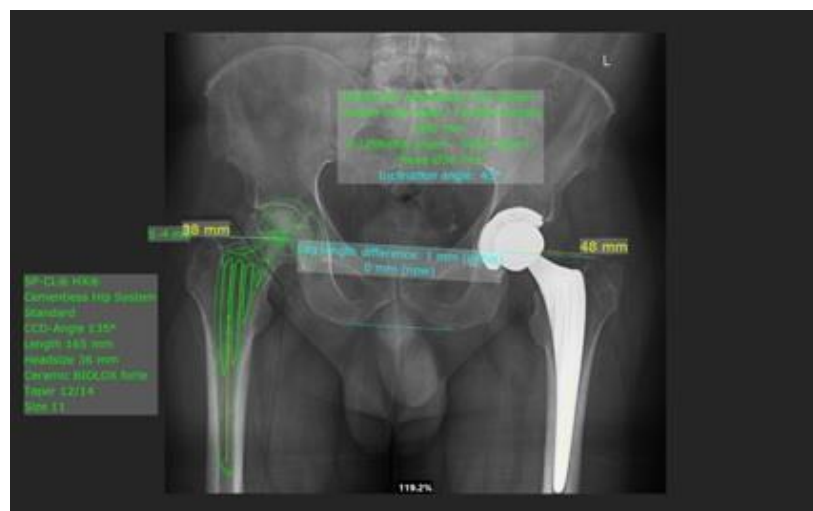


Fig.3 Preoperative planning



Fig.4 Postoperative X-ray



Fig.5 Preoperative planning



Fig.6 Postoperative X-ray

3 Results

The results are shown as a match between the planned implants and the definitively used ones. The tables show the differences between the planned dimensions of the capsule, stem and neck length and the definitive implants.

Acetabular component

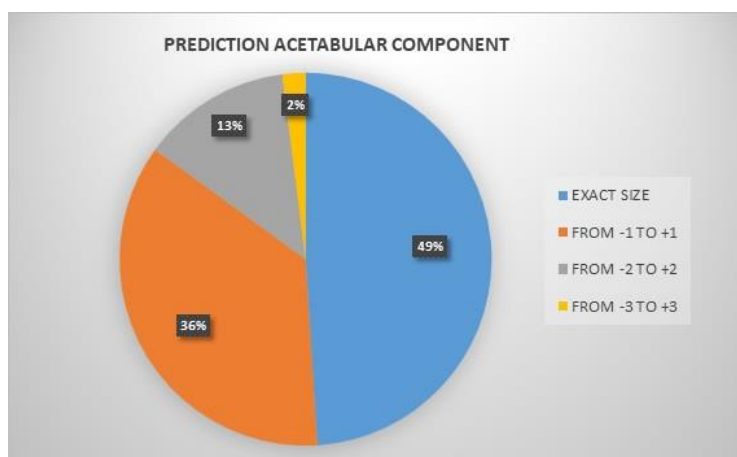


Fig.7 Acetabular component

The average size of the implanted capsules was 54 mm. (52mm-60mm.). The correct implant size was predicted in 49 % of cases. One size larger or smaller implant was

placed in 36 %. An implant two sizes larger or smaller was placed in 13%. 2 % had an implant 3 sizes larger or smaller. The match to +/- 1 size is 85 %.

Femoral component

We have an exact implant size in 45 %, +/- 1 size is placed in 37 %. At 12% +/- 2 sizes, 4 % +/- 3 sizes and 2 % +/- 4 sizes. The fit to +/- 1 size is 82 % and to +/- 2 sizes is 94 %.

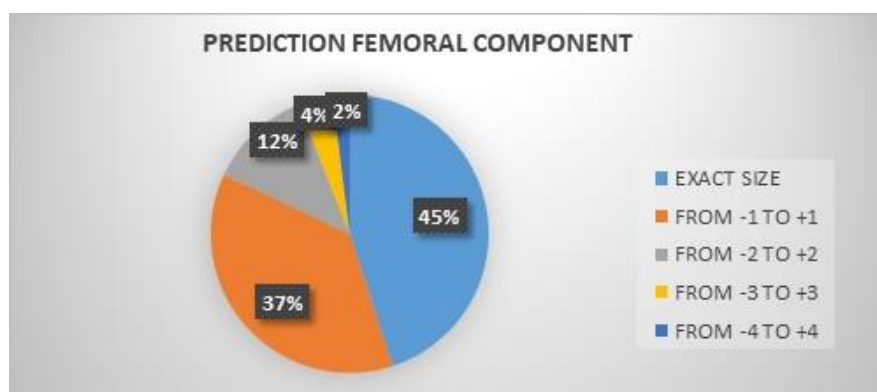


Fig.8 Femoral component

4 Discussion

Digital templating is becoming the preferred method for preoperative planning in THA. The available new technologies reduce inconsistencies and errors can be minimized. The information gathered during the planning process can be stored and used as needed. The learning curve is short, and the software is easy to use, allowing automatic planning, where only the correction of errors made by the system is necessary.

The MediCAD software allows the use of images in DICOM format. Image calibration is performed with a radio-positive calibration marker placed at the level of the greater trochanter. A planning error may occur if the marker is placed incorrectly.

Our experience shows that the MediCAD software predicts with accuracy up to +/- 1 size in 85 % of the acetabular components placed, and 82 % in the femoral component. These results are comparable to those reported to date in the literature. Wademeyer et al., conducted a study with the MediCAD software in 40 patients with the following results: 92 % accuracy within two dimensions for the acetabular capsule and 95 % accuracy within one dimension for the stem¹⁵. A study by Gamble et al. reported accurate prediction in 38 % of cases and 80 % with a difference of up to 1 size in the acetabular component. For stems, accuracies were 35 % and 85 % to 1 size,

respectively⁴. A study by Shaarani et al. showed an absolute accuracy of 38 % for the capsule and 36 % for the stem¹⁰. The largest study by Seyed Peyman M. et al. consisted of 391 patients. Data show that the MediCad software achieved an accuracy of 83.1 % within +/- 2 size of the acetabular component and 78.6 % +/- 2 size of the femoral component¹⁶. Ström et al. state that the precision in the use of digital templating does not depend on professional experience¹². Steinberg et al. report very good results using the TraumaCad software. In their study, the measured acetabular component +/- 1 size was accurate in 89 % of patients. Accuracy of the femoral component was predicted within 1 size in 87 % and within 2 sizes in 96 % of patients¹¹. In a study by The et al. prediction of the femoral component was 66 % within 1 size and 52 % for the acetabular component +/- 1 size¹⁴. Using EndoMap software, Davila et al. reported 72 % prediction for the capsule and 86 % for the stem³.

5 Conclusion

In conclusion, digital preoperative planning is an important step in performing total hip arthroplasty. The MediCAD (GERMANY) software is an efficient and precise method for predicting the final dimensions of acetabulum and femur implants, determining the correct cervical-diaphyseal angle, restoring biomechanics and limb length differences, leading to improved functional results after performing a total arthroplasty. The software is easy to use and there is no need for a long learning curve. The results we achieved are comparable to other studies performed.

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