A Simple Technique for Alignment in Total Hip Resurfacing Arthroplasty: Technical Note and Preliminary Report

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Abstract The functioning and survival of hip resurfacing arthroplasty depends on correct positioning and alignment of the implant. Correct positioning of the femoral alignment wire with respect to the femoral neck is the key to avoiding complications. Although the surgeon must align the wire in two planes, we can only control one plane at a time without changing position or relying on the indications of an assistant. Independent placement of two parallel alignment wires, one for varus-valgus orientation and another for version orientation, will help to determine two planes, the valgus sagittal plane and the version coronal plane, at the intersection of which both the optimum point of entry into the femoral head and the orientation line of the femoral alignment wire can be established. The marks on the neck and head and Kirschner wires following these marks define the planes. This simple technique allows us to reduce surgery time, minimize

errors, and speed up the learning curve. It can be used with any type of resurfacing arthroplasty.

Keywords resurfacing · alignment technique · hip arthroplasty

Introduction

The favorable results of total hip resurfacing arthroplasty depend on an adequate surgical technique and patient selection [1, 2]. Improvements in surgical technique, better instrumentation [3], assistance from intraoperative fluoroscopy [4], and navigation [5–8] may help to optimize the position of the femoral component. Further, improvements in technique may help prevent femoral neck fractures resulting from incorrect alignment or notching of the femoral neck [9–14].

Without navigation, the main problem for the surgeon is the need to place the alignment wire in two different planes, valgus and version, with no external references. It is only possible to observe and control one plane when the wire is inserted. Another plane remains blind, and it is, therefore, necessary to rely on the input of an assistant. The surgeon can also change position to observe both planes, although this means that the position of the surgeon's hand also changes, resulting in multiple trials and modifications in wire positioning until the alignment is considered correct. These maneuvers are tedious, imprecise, and make the learning curve dependent on the ability and experience of the assistant.

Our technique is based on a simple trigonometric principle: a line is always created when two planes intersect. It tries to simplify the positioning of the femoral head guidewire by dividing it into simple, consecutive, and reproducible steps instead of a single and complicated one. These steps help the surgeon to visualize the aforementioned planes simultaneously. The three main steps of the technique are defining the valgus sagittal plane (perpendicular to the coronal plane at the desired shaft-neck varus-valgus angle), defining the version coronal plane (perpendicular to the sagittal plane at the desired shaft-neck anteversion angle), and positioning the alignment wire at the intersection of these planes. These planes are defined by correct positioning of

A video showing this technique has been included at the Educational Media Electronic Library of the AAOS. (76th AAOS Meeting, Las Vegas 2009). Both the video and this study are dedicated to the memory of Richard S. Laskin, MD, for his teachings and humanity.

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Each author certifies that his or her institution either has waived or does not require approval for the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research.

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supplementary Kirschner wires in an attempt to increase the reliability of the usually insufficient marks drawn on the femoral neck and head.

This work aims to verify whether the insertion of supplementary wires allows us to position the guidewire more accurately, thus, reducing the variability associated with this step. In addition, we believe that the technique improves the accuracy of this complicated step allowing us to reduce operative time and incision length, without compromising the positioning of the implants.

Material and methods

Two nonrandomized consecutive series were compared: 15 patients underwent a standard procedure, without fluoroscopy or additional tools, and 31 underwent the procedure we describe below. All patients received a Durom hip resurfacing prosthesis (Zimmer™).

To be included in the study, patients had to be young and active and below 55 years of age with osteoarthritis of the hip, minor dysplasia, or femoral necrosis without collapse or severely distorted anatomy.

Patients were excluded if they were indicated for total hip arthroplasty, had renal insufficiency, hypersensitivity to metals, severe deformity of the proximal femur including varus deformity $\leq 130^\circ$, large femoral cysts, leg-length discrepancy greater than 1 cm, inflammatory diseases, obesity ($\text{BMI} \geq 35$), and necrosis affecting more than 40% of the femoral head. We also excluded patients with mild or severe dysplastic hips during this early phase in our learning curve.

We use a standard posterolateral approach. The alignment wire must be centered on the femoral neck in order to reduce the risk of notching the anterior or superior neck cortices, which are the areas of greatest risk of neck fractures. If the alignment wire is centered on the femoral head, it will be posterior and inferior to the center of the neck, leading to a limited arc of motion in flexion, abduction, and external rotation. Our technique involves two independent planes. At the point where these planes intersect, we can establish an entry point that enables us to position and align our guidewire. The surgeon can only visualize both planes simultaneously once they have been previously defined individually. This technique does not require fluoroscopy or specific tools. First, using the diathermal scalpel, we mark the midline of the femoral neck in the valgus, sagittal plane. A compass or neck calipers enable us to determine the center of the neck (Fig. 1a, b), and the long-tip scalpel defines a straight line (valgus line) that should be cephalad to the center of the femoral head.

Next, a wire is drilled into the intertrochanteric ridge parallel to the midline of the femoral neck, which has previously been drawn over the bone and cartilage. This wire should be placed tangential to the femoral head but not leaning on the posterior side of the neck. The more tangential this wire, the valgus wire (i.e., the wire defining the neck-shaft varus-valgus angle), is inserted, the more parallel it will be to the second wire, the version wire (i.e., the wire defining the version angle; Fig. 1c–e). The more convergent to the femoral neck the valgus wire is inserted

(leaning on it), the more retroverted it will be (Figs. 2a, b, 3). If the valgus wire is not inserted into the intertrochanteric ridge tangential to the femoral head, it will still be in the valgus plane, but it will not be as helpful for the next step, the insertion of the version wire (Fig. 4).

Deviations due to the wire's flexibility can be minimized in two different ways: resting the wire on the femoral head and following the line previously drawn on the head and neck or using a cannulated guide that is narrow enough to enable the surgeon to see the parallelism with the previous marks or with other inserted wires (Fig. 5a). The latter procedure is our preferred method. We recommend performing steps 1 and 2 from the assistant's side.

We repeat the procedure with the version angle by marking the superior-lateral surface of the femoral neck and head with the diathermal scalpel. This line should cross the valgus line dorsal to the fovea capitis femoris as the valgus line has been centered on the middle of the femoral neck, not on the middle of the femoral head (Fig. 1b). A second wire following the line that determines femoral anteversion is drilled close to the piriformis fossa and parallel to the first wire (Figs. 5b, 6). If we insert the version wire nonparallel to the valgus wire, it will still be in the version plane, although it will not be so helpful for the next step, the insertion of the alignment wire (Fig. 7). The lines marked over the neck and head and their corresponding wires constitute a plane. Therefore, each plane has now been independently defined, and the surgeon can see both planes directly. The definitive alignment wire must be placed at the intersection line of these previously defined planes (Fig. 8a, b). Ideally, this wire should be parallel to the previous wires (Fig. 9a, b), but the shape of the femoral neck sometimes means that the version wire is difficult to place completely parallel to the valgus wire. Nevertheless, the alignment wire has to be included in both planes (Fig. 10), even if it is sometimes slightly convergent to the second wire. The closer the tangential wires are located to the circumference of the femoral head, the more parallel they will be, thus, making it easier to insert the definitive wire. Before drilling the head and neck, we can place the same cannulated guide on the third wire and check with the outside caliper that there is no risk of notching. If the position of the wire is considered correct for varus-valgus and version alignment but we wish to move it with respect to the selected midline of the neck, a second wire parallel to the first one can then be inserted by moving the entry point of the first wire by 2 to 3 mm using a multihole templating guide to avoid modifying its direction (Fig. 11a). A new check is performed (Fig. 11b) before reaming over this second wire. This maneuver may be necessary in cases with severe deformity of the femoral head or important femoral neck–head offset.

We now proceed to drill and ream the femoral head. The usual recommendations are observed. These include resection of femoral neck osteophytes to avoid impingement, taking special care not to over-resect and, thus, leave reamed bone uncovered by the implant. Both of these situations could cause stress points leading to neck fractures. Maximum bone-implant contact and good bone-cement interdigitation avoiding a very thick cement mantle will prevent cement failure or

Fig. 1. **a, b** The caliper helps to draw the midline of the neck in valgus and version angle. The valgus line is dorsal to the fovea capitis femoris. **c, d, e** Cephalic view of the lines and the wires

fractures of the stem of the prosthesis [2]. Our final step, which is not related to the alignment technique, is to measure the distance from the dome of the head to a reference point in the intertrochanteric line using a rule or a caliper. This distance is checked with the trial femoral head before inserting the definitive one. The purpose of this maneuver is to ensure the final implant is fully seated, preventing the above-mentioned complications.

Preoperative and postoperative antero-posterior and frog-leg lateral radiographs were evaluated by an author (ARL) who did not participate in the procedures. The “ideal angle” (shaft-neck varus-valgus angle) and version alignment were defined taking into account the position of the templates on preoperative radiographs (simulating the position that would ensure that the femoral neck cortex is not notched).

The outcome measures analyzed were the use of the wires or not (dependent variables) and its relation to

operative time, incision length, varus-valgus and version alignment, and deviations from the “ideal position” (independent variables). Other independent variables analyzed were age, primary diagnosis, body mass index, and sex.

The Kolmogorov–Smirnov test was used to determine whether the quantitative variables had a normal distribution. In this case, the *t* test or ANOVA for independent measures was used to compare the means of two or more groups in the bivariate analysis. If the variables did not have a normal distribution, nonparametric methods (Mann–Whitney *U* test or Kruskal–Wallis test) were used. Quantitative variables were assessed using the Pearson’s correlation coefficient, and when distributions were not normal, a nonparametric correlation method, such as Spearman’s ρ was used. The chi-square test was used for the bivariate comparison of proportions. A *P* value (two-tailed) <0.05 was considered statistically significant. Data were analyzed using SPSS version 11.5.

Fig. 2. a, b Cephalic and axial representation of the alignment. The dotted lines delineate femoral neck orientation

Results

There were no differences regarding age, primary diagnosis, body mass index, or sex. All but two patients were men with a mean age of 41 years (33–54). The primary diagnosis

was osteoarthritis in all but eight patients with femoral head necrosis, three in the first group, and five in the second. Mean follow-up was 19 months (5–36 months).

The use of the guidewire technique resulted in more accurate placement of the femoral component in both

Fig. 3. X-ray of a well positioned and of a retroverted prosthesis. The lines represent the theoretical position of the wires

Fig. 4. Different views of the varus-valgus wire and plane. The tangential wire is parallel to the final alignment wire. The dotted lines delineate femoral neck orientation

varus-valgus alignment ($P<0.001$) and version alignment ($P<0.1$). In the group in which the guidewires were not used, the mean valgus angle was 139° ($125\text{--}150^\circ$), the mean varus-valgus deviation was 6.5° ($0\text{--}12^\circ$) with respect to the ideal position, and the mean version deviation was 6° ($0\text{--}15^\circ$) with respect to the ideal position. Mean

operative time and incision length were 121 min ($100\text{--}135$ min) and 18 cm ($15\text{--}22$ cm), respectively. In the guided group, the mean valgus angle was 138° ($132\text{--}145^\circ$), the mean varus-valgus deviation was 3.3° ($0\text{--}7^\circ$) with respect to the ideal position, and the mean version deviation was 3° ($0\text{--}8^\circ$) with respect to the ideal position. Mean operative time and incision length were 112 min ($95\text{--}125$ min) and 14.5 cm ($9.5\text{--}17$ cm), respectively.

The length of the incision was significantly reduced by using the wires ($P<0.001$), as was operative time ($P<0.001$). Of the independent variables, only incision length was related to operative time ($P<0.04$).

At the end of follow-up, one patient in the nonguided group had undergone surgery 1 year after the first operation due to a femoral neck fracture. The X-ray revealed no large alignment deviation, and the failure may have been due to inadequate cementing. The mean length of hospital stay was 4 days for both groups.

Fig. 5. a, b Insertion of the wires following the lines. The cannulated guide prevents the wires from bending

Fig. 6. The wires are placed parallel following the marks on the bone and cartilage

Fig. 7. Different views of the version plane. The tangential wire is parallel to the final alignment wire. *Dotted lines* delineate femoral neck orientation

Fig. 8. **a, b** Position of the wires on a plastic femur. The intersection of two planes defines a line for definitive alignment

Fig. 9. **a, b** The definitive wire is inserted parallel to both previously inserted wires

Fig. 10. Illustration of the wires and planes. Lateral, oblique, and posterior-anterior. The wires are tangential to the circumference of the femoral head

Discussion

The purpose of this study was to determine if a guidewire technique can improve the accuracy of placing the femoral head prosthesis in hip resurfacing procedures. Accurate positioning of the implant is of paramount importance to ensure low wear of metal-on-metal bearings and to avoid complications such as prosthesis-bone impingement, soft tissue impingement, or femoral neck fracture [9, 10, 15–18].

The major difficulty for the surgeon is the need to place the alignment wire in two different planes, the valgus and version planes, using only minimal external references or landmarks. Implementing these landmarks using a “step-by-step” insertion of Kirchner wires may help the surgeon to visualize the planes and the femoral neck anatomy simultaneously, thus, reducing variability in the positioning and alignment of the guidewire. Our approach could also allow a safe reduction in incision length and operative time.

In order to minimize deviations in the positioning of the components, surgeons have introduced improvements in surgical instruments, intraoperative fluoroscopy, and navigation [3, 4, 19]. Navigation, when used alone or in combination with computed tomography or intraoperative fluoroscopy, may be the most reliable option, although it is not universally available and may prolong the procedure. It can reduce axis alignment deviations to below 5° of the preoperative templates and help to accelerate the learning curve [5–8]. However, differences are not always significant, and some authors propose that navigation is more useful in dysplastic hips or in combination with minimally invasive techniques. The use of preoperative X-ray to correctly position the wire in both planes may also require a change in position for the surgeon, unless we use double-beam fluoroscopy. Depending on the approach adopted, it may also require a change in position for the patient once the wire is inserted, and this could prolong operative time [4]. Any intraoperative aid that allows surgeons to reliably

place the femoral component at the planned angle can reduce inconsistencies in surgical technique, especially during the early phases of the learning curve.

Without Kirchner guidewires, varus-valgus and version deviation from the ideal position averaged 6.5° (0 – 12°) and

Fig. 11. **a** Moving the position of the wire 2 mm without changing the alignment. We use a multicannulated guide for this step. **b** With the caliper in the new position, the diathermal scalpel has been inserted in the entry point to illustrate the previous position of the guidewire

6° (0–15°), respectively. With Kirchsner guidewires, varus-valgus and version deviation averaged 3.3° (0–7°) and 3° (0–8°), respectively. Operative time and incision length were also significantly reduced with the use of the Kirschner wires (although more difficult cases may require more extensile exposures). The major bias of our series, other than sample size, is that the groups were not randomized.

Our series is too small to establish a learning curve for resurfacing arthroplasty or to allow a “safe” reduction in incision length, even more so given that this procedure is only recommended after a broad experience or when accompanied by navigation [3, 8, 9, 20, 21]. Therefore, we related the elimination of major alignment mistakes to the change in our technique. Our preliminary data show that the procedure could be useful and, to some extent, widely reproducible, as all systems involve some preliminary steps aimed at positioning the guidewire correctly. We observed that modifying the technique did not affect the learning curve but that it has allowed us to position the guidewire more accurately, while progressively reducing operative time and the length of the incision. This “step-by-step” technique for defining the planes and increasing the liability of the marks on the femoral head and neck may help surgeons to minimize technical errors and to learn more from their mistakes, thus, accelerating the learning curve.

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