Digital Templating in Total Hip Replacement

a report by

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Preoperative planning is helpful in achieving a successful result in total joint replacement. Most reconstructive surgeons routinely template radiographs prior to performing total hip arthroplasty. Having preoperative information on appropriate implant size and position improves operative efficiency and facilitates the desired result. Preoperative templating in total hip replacement helps familiarize the surgeon with the bony anatomy prior to surgery, reducing surgical time as well as complications. Typically most reconstructive surgeons have used acetate overlays and radiographs to determine appropriate implant size. This method has been reasonably accurate in hip arthroplasty even though radiographs have varied magnifications due to differences in technique and soft tissue mass which do not always match the given magnification of overlays.

Improvements in technology have produced digital imaging and PACS, which are now prevalent and are being used by an increasing number of hospitals and clinics. The trends driving PACS are the same ones pushing general radiography toward digitization. With digital radiography and computed radiography, a Digital Imaging and Communications in Medicine (DICOM) archive is generated for either a standalone PACS network or a Web based PACS functionality. Digital images replace radiographs, which can no longer be lost or misplaced in a completely filmless system. X-ray images are viewed on a diagnostic grade monitor, rendering prosthetic overlays useless. Digital templating software is now available which can be used with various digital X-ray servers. The incorporation of the various templates into the software in terms of the ‘magnification factor’ is essential for accurate preoperative templating and planning.

The present study was performed to evaluate the accuracy of specific templating software (with emphasis on femoral component fit) and compare it to the traditional technique using standard radiographs.

Materials and Methods

A total of 40 hips in 39 patients were studied retrospectively. All preoperative templating information was recorded and compared to operative reports and vendor labels. All surgery and preoperative templating was performed by one surgeon. All radiographs were templated with standard overlays which were 120% magnified. All X-rays (except the pelvis view) were taken with a 10cm magnification marker which is an acrylic stick with a metallic bead imbedded at each end. Magnification was determined by a calibration tool in the software, which then automatically adjusted the digital template accordingly. For radiographs the magnification marker was measured by hand with a ruler to establish the magnification. All digital templating was performed on the same PACS workstation using the same templating software (Traumacad, Tel Aviv, Israel).

An uncemented Synergy femoral component (Smith and Nephew, Memphis, TN) and Reflection cup were used in all hips. The femoral implant is a tapered titanium alloy stem with proximal porous coating. The cup is a porous coated titanium shell with a proportionally expanded rim. The study group was comprised of patients that had surgery performed just before and after our institution acquired the software. Twenty consecutive hips using radiographs (just prior to acquiring a PACS) were compared to 20 consecutive hips that were templated digitally after the software was obtained. Digital templating and surgery was performed without allowing for learning curves. All patients had Dorr type A or B bone and the use of this particular femoral component was considered appropriate. There were no unusual deformities or bone deficiencies in all 40 hips.

All charts were reviewed and surgery date, age, sex, and diagnosis were recorded. There were 37 hips with osteoarthritis and three with avascular necrosis. All patients had standard AP, Lauenstein lateral, and pelvis X-rays preoperatively and AP and lateral X-rays at six weeks, three months, and six months postoperatively. All X-rays were performed by two radiology technicians using a Eureka Linear MC150 collimator using a 40-inch tube to film distance. A 10cm magnification marker was taped to the skin laterally over the greater trochanter for the AP view and taped anteriorly at the proximal femur for the lateral view. Digital images were
produced by computed radiography (Konica-Minolta, Wayne NJ) and stored on a PACS server (Novapacs, American Fork, UT). Magnification was determined on radiographs by measuring the magnification marker by hand and using this information when choosing an appropriate size template. Standard proprietary acetate overlays were used which were 120% magnified. When choosing between sizes, if the radiographic magnification was less than 120%, the larger size (template) was chosen; if the magnification was greater than 120%, the smaller size template was chosen. Digitally, a calibration tool in the software was utilized to determine the magnification of each image, and the magnification of the digital template was automatically adjusted. The magnification range was 116% to 124%. The template files were acquired digitally from the each manufacturer, and incorporated into the software in DXF file format.

In all cases the surgeon was aware of the preoperative templated data at the time of surgery. Radiographs and digital images were templated utilizing common objectives of canal filling and fit. Optimal femoral neck resection was around 1–1.5cm above the lesser trochanter and was estimated from the templated image or radiograph. Offset and radiographic leg length measurements were estimated but not recorded or analyzed.

Thirty-eight hips were performed through a mini incision posterior approach and a standard posterior approach was used in two hips. Surgical technique was similar in all cases with the intent of optimal fit, fill, and femoral component stability within the femur. The endosteal canal was conically reamed by hand in incremental sizes until the proximal isthmus was engaged, and then the femur was broached to that size. If the broach was felt to be axially or torsionally unstable (undersized), distal reaming was increased by one or two sizes until optimal fit of the broach was obtained. Postoperative X-rays were followed to a minimum of six months and examined for fractures or subsidence.

The study group included 17 (44%) males and 22 (56%) females. Patient ages ranged from 41 to 82 years (mean age 67 years). One female patient had bilateral surgery. There were 20 left hips and 20 right hips. All patients underwent total hip arthroplasty using the same components. A cross-linked polyethylene liner was used in all cases. A chrome cobalt femoral head was used in 37 hips and oxinium used in three. All except three acetabular components were inserted without screw fixation. Typically the acetabulum was under reamed by 1mm or reamed line to line with the cup size, which has a flared rim. There were no cases with atypical femoral anatomy or acetabular protrusio.

Postoperative X-rays were analyzed for femoral component fit using Callaghan’s criteria, which was modified to account for this stem geometry. The fit was considered excellent if the stem was in contact or within 1mm of cortical bone at some point on both the medial and lateral stem surface (or anterior posterior surface) on either the anterior posterior or lateral X-ray. The midportion of the stem was consistently analyzed starting at the distal edge of the porous coating to a point 5cm distal (before the stem tip tapers off). The fit was considered to be good if the stem was within 2mm at some point on the medial and lateral (or anterior posterior) stem surface on either the anterior posterior or lateral X-ray. The distance between the calcar resection level and the top edge of the porous coating was measured on the immediate postoperative, six-week and three-month X-ray. A change of greater than 3mm was considered subsidence.

**Results**

Hospital records and operative notes were reviewed on all patients. There were no intraoperative fractures or complications. There were two postoperative complications. One patient sustained a single postoperative dislocation treated closed successfully, and a second patient with early dementia developed recurrent instability treated with acetabular revision using a constrained liner with a satisfactory result. Clinically, there were no significant differences between the two groups. Two patients in each group had mild thigh pain.

The actual size implant used for each patient was compared with the preoperative templated size. Using radiographs and overlays, six hips (30%) were the same size as templated, 13 were different by one size (65%), and one hip (5%) was two sizes different. With the templating software and PACS images, 12 hips (60%) were the same size as templated preoperatively, seven hips (35%) were different by one size, and one (5%) was different by two sizes. For both groups 100% were within two sizes and 95% were within one size; in the PACS group a larger percentage were the same size as planned.

For femoral components that were not the same size as planned, with digital templating 75% of hips were underestimated in terms of size (five by one size and one by two sizes) and 25% were overestimated by one size. With film 64% were underestimated (eight by one size and one by two sizes) and 36% were overestimated by one size.
Cup size was also examined. In radiographs cup size was the same as templated in 10 (50%) hips. In nine hips (45%) acetabular size was different by 2mm, and one cup (5%) was different by 4mm. Eighty per cent of these acetabular components were underestimated in size and 20% overestimated. With digital images nine hips (45%) were the same size, seven (35%) differed by 2mm and four (20%) differed by 4mm. Among these 11 hips, 82% were underestimated in size and 12% were overestimated. Comparing radiographs to digital, cup size was within 2mm of the planned size in 95% and 80%, respectively.

Statistical analysis to examine difference between templated and actual implant size were conducted using STATA v.8. Differences were tested for using chi square and Fisher’s exact test for categorical data and t-tests for proportions and continuous data.

Postoperative X-rays to six months showed no subsidence or changes in femoral (or acetabular) component position in all hips. There were no significant differences in stem fit between the two groups. In hips using the standard technique stem fit was excellent in 70% and good in 30%. In the digital group stem fit was excellent in 75% and good in 25%. There were no stems with poor fit.

Discussion

Many hip surgeons routinely practice preoperative planning in joint replacement surgery. Planning entails several variables and considerations such as bone quality, patient activity level, choice of implant, leg length, offset, mode of fixation, bony deformity or deficiency, bearing surfaces, and economic issues. Preoperative templating for appropriate size, fit, and position of the implants addresses many of these variables before surgery is performed. The templating process optimizes surgical accuracy and reduces operative time and should lead to a more durable result with fewer complications, particularly in uncemented femoral components. Unanticipated problems are issues with leg length inequality; intraoperative fracture, and instability may be avoided. Problems with implant inventory are avoided when this information is communicated with hospital operating rooms prior to surgery.

This preliminary study examines the accuracy and usability of digital templating as compared to the standard method using radiographs.

This article is continued, with references, graphics and tables, in the Reference Section on the website supporting this briefing (www.touchbriefings.com).