Do RSA measurements of acetabular cup stability and polyethylene wear improve by adding tantalum beads to the liner?

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INTRODUCTION: Radiostereometric analysis (RSA) is a useful tool for early measurement of femoral head penetration and acetabular cup stability in total hip replacements (THR). Because the polyethylene liner is assumed to be stable in the shell, the liner and shell are often assigned as one combined segment (shell + liner) in RSA. However, when beads are inserted into the liner, the liner and shell can be separated into two individual segments using a markerless shell that does not require the insertion of tantalum beads.

Previous phantom and *in vivo* RSA studies have indicated that a combined segment might give an optimal precision.[1,2] The *in vivo* RSA study demonstrated that wear measured using shell + liner, liner only or shell only yields comparable results.[2] However, the shell + liner method utilizes the greatest amount of information in the radiograph, making it the preferable method. The purpose of this study was to determine if RSA measurements of wear (femoral head penetration into the polyethylene liner) and acetabular cup stability in the pelvis were influenced by assigning the shell and liner as one combined or two individual segments in a continuous *in vivo* follow-up study.

METHODS: 51 consecutive THR RSA hips (47 patients) from our center gave informed consent to receive tantalum beads inserted into their pelvis and polyethylene liner. RSA radiographs were analyzed with UmRSA software (Umeå, Sweden) to measure motion (translation and rotation in the y-direction) of the femoral head, liner, and cup (Table 1). Double exams were conducted at least once for each patient and were used to establish the precision of the radiographic setup. The Wilcoxon paired signed ranks test was used to determine differences among the measurement methods.

Table 1: Measurement segments defined

Segment	Assigned Markers
Head	Automated edge detection of femoral head to determine center
Liner	Up to 9 beads labeled in polyethylene liner
Shell	5 points automatically assigned to acetabular back-shell using edge detection (markerless)
Shell + liner	Up to 6 beads labeled in polyethylene liner and 3 points automatically assigned to the back-shell
Pelvis	Up to 9 beads labeled in the pelvic bone

RESULTS: As 4 of the hips were excluded due to a mean error >0.25, 3 patients have not reached 6 month follow-up, and one patient was revised before 6 months; 43 hips were included in this RSA analysis. When compared to the shell, the median polyethylene liner migrated 0.03mm in the distal direction (Table 1). This translation was within the error of detection for this method as determined by double exams.

Median femoral head penetration into the polyethylene varied among the measurement methods (Table 2). Head penetration measured into the liner segment was not significantly different from the penetration measured using the shell + liner segment. However, both the head to liner and the head to shell + liner segments measured significantly higher penetration than the femoral head compared to the shell alone ($p \leq 0.03$). The median bead count and condition number was 5 and 52 for the liner segment versus 7 and 24 for the shell + liner segment.

Calculated acetabular cup translation was significantly different when comparing the pelvic bone beads to the shell + liner segment versus the pelvic beads to the shell alone ($p=0.04$). There was no difference found in cup rotation between these measurement methods.

Usable double examinations of RSA images were obtained for 44 of the 46 hips. Precision for wear measurement was highest in the head to liner method (Table 3). For cup migration and rotation, the shell + liner method had higher precision (Table 4). The median bead count and condition number at all follow-ups was 5 and 26 for the shell segment versus 7 and 24 for the shell + liner segment.

Table 2: Polyethylene liner motion in the shell. Median±SE (95% CI)

RSA Method	PO-6 months	Precision
Shell Translation (mm)	-0.03±0.03	-0.03, 0.06
Shell Rotation (degrees)	0.17±0.35	-0.17, 0.42

Table 3: Femoral head penetration (mm). Median±SE (95% CI)

RSA Method	PO-6 months	Precision
Liner	0.04±0.01	-0.03, 0.02
Shell	-0.01±0.02	-0.07, 0.01
Shell + Liner	0.03±0.01	-0.09, 0.03

Table 4: Acetabular cup motion versus the pelvis. Median±SE (95% CI)

RSA Method	PO-6 months	Precision
Shell Translation (mm)	0.14±0.03	-0.03, 0.03
Shell + Liner Translation	0.12±0.03	-0.02, 0.02
Shell Rotation (degrees)	0.01±0.39	-0.19, 0.28
Shell + Liner Rotation	-0.11±0.09	-0.09, 0.18

DISCUSSION: The motion seen between the polyethylene liner and the shell (table 2) was not greater than the precision in the RSA setup. The amount of measured translation and rotation were too small to be able to definitively determine if the liners were moving within the shells.

Beads should however be placed in the polyethylene liner because wear measurement of the femoral head into the liner segment was significantly different than that comparing the head to the shell alone (table 3). Additionally, the head to liner comparison was able to measure a head penetration into the polyethylene liner, which the head to shell + liner and head to shell alone failed to do, as the motion was within the precision of the method. Although the head to shell + liner comparison did not detect wear or creep, the median translation was equal to the upper limit of the confidence interval, therefore the calculated median translation of the head into the shell + liner fell just short of verified wear.

Since the condition number was higher and the bead count was lower for the head to liner versus the head to shell + liner method, this confirmed that using the shell + liner segment allowed the program to utilize a greater dispersion of measurement points within the patient and therefore, more information in the radiograph.

The presence of beads in the polyethylene also improved the ability to measure motion of the acetabular cup. The shell + liner method showed detectable translation and rotation as compared to the pelvis, whereas the shell alone showed detectable translation only. Since the polyethylene beads allowed for additional information defining the cup segment (up to 9 points), versus the shell method (up to 5 points), more of the radiograph's information was utilized which increased the precision of the RSA setup.

SIGNIFICANCE: Beads should be inserted into the polyethylene liner, as a separate liner segment appears to give a more precise measurement of head penetration into the liner in RSA studies of polyethylene wear. Including the polyethylene beads when measuring the shell segment improves the precision of cup stability measured with RSA as well.

REFERENCE:

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