ORIGINAL

Impact of surgeon experience on the effectiveness of patient-specific instrumentation in reverse shoulder arthroplasty

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Abstract : Scapular models were created based on preoperative computed tomography images obtained for 8 cases of cuff tear arthropathy that underwent reverse shoulder arthroplasty (RSA). Four surgeons performed baseplate implantation : A, a shoulder surgeon with experience of more than 200 RSA cases ; B, an arthroscopic shoulder surgeon with experience of fewer than 10 RSA cases ; C, an orthopedic fellow ; and D, an orthopedic resident. Implantation was performed using the conventional method and using patient-specific instrumentation (PSI). Overall, the mean ΔInc was 9.1° using the conventional method and 3.7° using PSI ; the respective mean ΔVer were 3.7° and 3.2°. Using the conventional method, there were statistically significant inter-surgeon differences in ΔInc ($p = 0.038$) but not in ΔVer ($p = 0.77$). Using the PSI method, there was no significant inter-surgeon difference in ΔInc ($p = 0.89$) or ΔVer ($p = 0.23$). There was a statistically significant intra-surgeon difference in ΔInc for surgeons B and C (B, $p < 0.001$; C, $p = .007$) but not in ΔVer for any of the surgeons. PSI ensured the accuracy of baseplate implantation in RSA regardless of a certain amount of surgeon's experience. Implantation accuracy was more impacted when the surgeon was less experienced. J. Med. Invest. 73 : 217-221, February, 2026

Keywords **:** *reverse shoulder arthroplasty, glenoid baseplate, patient-specific instrumentation, surgeon experience, baseplate inclination*

INTRODUCTION

Correct baseplate positioning is essential in reverse shoulder arthroplasty (RSA) to avoid complications and is crucial for proper shoulder kinematics. Studies investigated the tilting angle have found that moderate inferior tilt is preferable for stability (1, 2). Moreover, biomechanical studies have suggested that placement of the implant affects the shoulder kinematics after RSA (1-3). Gutiérrez *et al*. found that a baseplate with an inferior tilt of 15° had more consistent compressive forces and less tensile force and micromotion than a baseplate with a superior tilt of 0° or 15° (1). Using a computational model, another study also found that the distribution of forces was most even with inferior tilt and uneven with superior tilt (2). In terms of clinical outcomes, superior inclination is associated with a decreased range of motion at the shoulder (4, 5). In view of these reports, a device that facilitates accurate placement of the baseplate has been developed and can now be used with computer navigation (6, 7) and patient-specific instrumentation (PSI) (8-11). Some reports suggest that PSI improves the accuracy of positioning of the glenoid component in anatomic total shoulder arthroplasty and RSA (8-11). However, there have been no studies of the effects of PSI using glenoid models, and it would be useful to know whether PSI guarantees accurate baseplate implantation for all surgeons. Therefore, the aim of this study was to determine the effect of surgeon experience on the accuracy of baseplate implantation using PSI.

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MATERIALS AND METHODS

The study was approved by the Institutional Review Board of NHO Kochi National Hospital (No R5-36), and written informed consent was obtained from all participants.

A model of the scapula was created using a three-dimensional (3D) Lepton2® printer (MagnaRecta, Tokyo, Japan) based on the preoperative computed tomography (CT) images of 8 patients (4 male, 4 female) with cuff tear arthropathy that was undergone RSA. The mean age of the patients was 78.3 years. Using the Hamada classification system (12), 3 patients were classified as grade 2, 2 as grade 3, 2 as grade 4A, and 1 as grade 4B. Glenoid deformity was assessed as A1 in 7 patients and A2 in 1 using the classification system devised by Walch *et al*. (13). Eight scapular model was created for each case. The baseplate model of Zimmer Trabecular Metal Reverse Shoulder System® (Zimmer Biomet, Warsaw, IN) was then implanted in these models by each of the 4 surgeons (A, B, C, and D) using the conventional method and the PSI method. Surgeon A was a shoulder surgeon with experience of more than 200 RSA cases (co-author S.F.), surgeon B was an arthroscopic shoulder surgeon with experience of fewer than 10 RSA cases (co-author D.N.), surgeon C was an orthopedic fellow (J.K.), and surgeon D was an orthopedic resident (co-author M.K.). The preoperative plan of implantation was estimated by ONE planner® (Zimmer Biomet, Warsaw, IN) with neutral inclination and neutral version based on the Friedman line (14). The plans were shared with all four surgeons before the implantation. The implantation was performed conventional method to all 8 cases firstly followed by PSI method. Each technique performed on the same day. Figure 1 shows the steps involved in implantation of the baseplate in a scapular model. The scapular model was hidden from view, as if in the body in actual surgery (Fig. 1a). The red line indicates use of the conventional method to implant the baseplate according to the preoperative plan and the blue line indicates use of the PSI method. First, the PSI guide (ONE planner guide®, Zimmer Biomet, Warsaw, IN) was

attached to the anterior border of the glenoid. Next, 2 guide pins were inserted with the guide, followed by reaming. The baseplate was then implanted using the guide pin and guide. After implantation, 3D CT scans of the entire shoulder were obtained for all the models. The CT data for each scan were transferred to 3D template software (ZedShoulder ; Lexi, Tokyo, Japan). The postoperative position of the baseplate was measured (Fig. 2), and deviations in inclination and version from the preoperative plan (ΔInc and ΔVer, respectively) were recorded as absolute values. The mean error with each implantation method and the number of outliers (defined as more than 10 degree of deviation from the planning for version or inclination) were compared among surgeons and within each surgeon.

Quantitative data were evaluated using the Mann–Whitney *U*

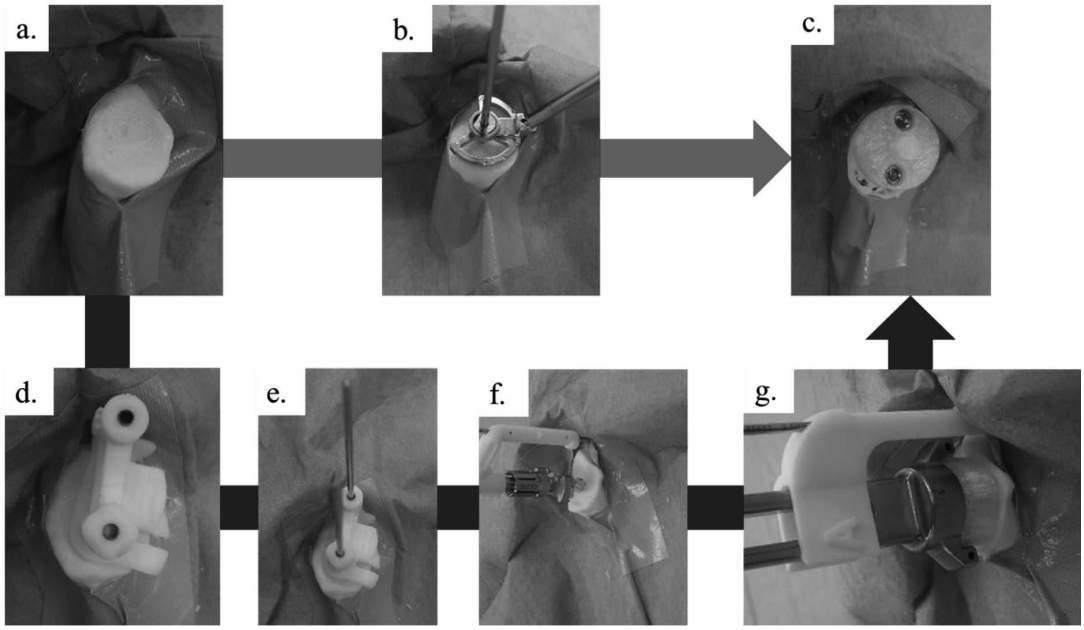

Figure 1. Steps involved in implantation of the baseplate in a scapular model. The scapular model was hidden from view, as if in the body in actual surgery (a). The red line indicates use of the conventional method (b, c). The guide pin was inserted using a conventional guide (b). The blue line indicates use of the patient-specific instrumentation method (d–g). First, the guide was attached to the anterior border of the glenoid (d). Next, 2 guide pins were inserted with the guide (e), followed by reaming (f). Implantation was also performed using guide pins and the guide (g).

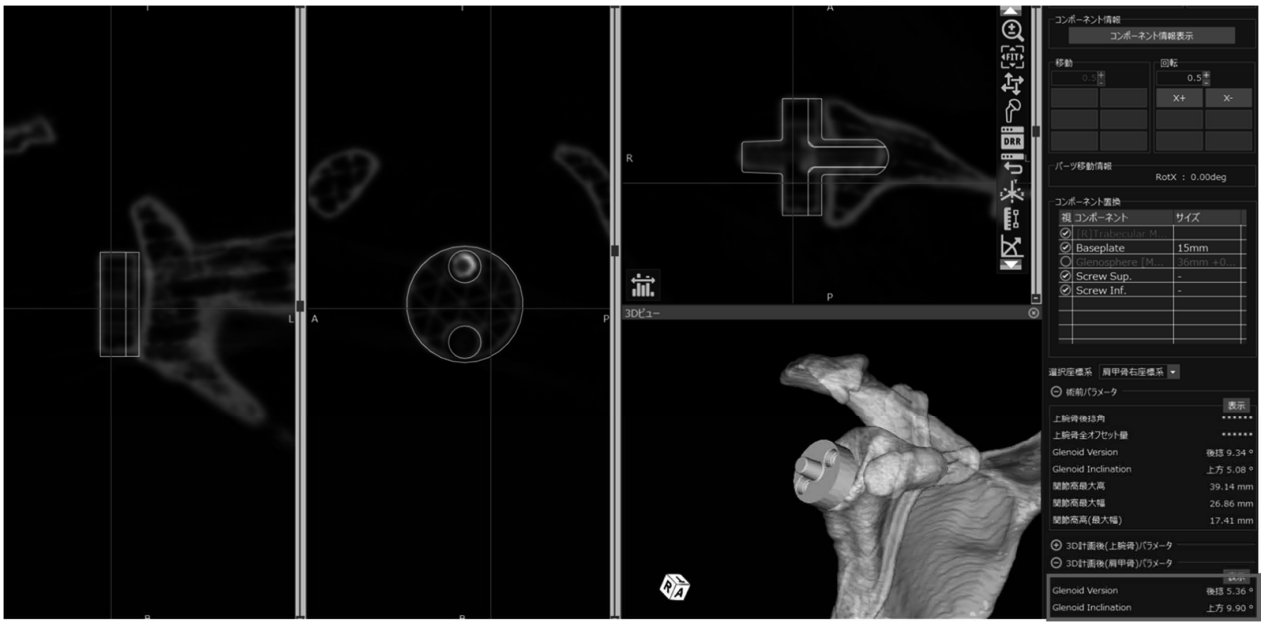

Figure 2. Positioning of the glenoid baseplate. The computed tomography data for each scan were transferred to three-dimensional template software (ZedShoulder, Lexi, Tokyo, Japan). The template was set with the planes. Inclination and version were measured correctly, as indicated by the red square.

test. The Kruskal–Wallis test was used to compare the results between 3 or more groups. Categorical data were evaluated using the Fisher's exact probability test. All statistical analyses were performed using SPSS Statistics version 27.0.1.0 software (IBM Corp., Armonk, NY, USA). The level of significance was set at 5%.

RESULTS

The distributions of the baseplate positions are shown in Figure 3. Overall, the mean ΔInc value was 9.1 ± 7.1° when using the conventional method and 3.7 ± 2.2° when using the PSI method. The mean ΔVer value was 3.7 ± 2.7° for the conventional method and 3.2 ± 2.6° for the PSI method. When the conventional method was used, there was a statistically significant inter-surgeon difference in ΔInc (A, 5.5 ± 3.8° ; B, 13.2 ± 4.6° ; C, 9.5 ± 6.3° ; D, 8.8 ± 10.0° ; p = 0.038) but not in ΔVer (A, 4.5 ± 2.0° ; B, 3.4 ± 1.6° ; C, 4.5 ± 2.4° ; D, 4.0 ± 2.6° ; p = 0.77). The number of the outlier was not statistically different for ΔInc (A, 1 ; B, 5 ; C, 3 ; D, 2 ; p = 0.26) or in ΔVer (A, 0 ; B, 0 ; C, 0 ; D, 0). When the PSI method was used, there was no statistically significant inter-surgeon difference in ΔInc (A, 3.0 ± 1.9° ; B, 3.9 ± 2.6° ; C, 3.7 ± 1.6° ; D, 4.3 ± 4.2° ; p = 0.89) or ΔVer (A, 3.2 ± 3.3° ; B, 2.8 ± 2.3° ; C, 4.6 ± 2.1° ; D, 2.1 ± 2.0° ; p = 0.23) The number of the outlier was not statistically different for ΔInc (A, 0 ; B, 0 ; C, 0 ; D, 0) or in ΔVer (A, 0 ; B, 0 ; C, 0 ; D, 1 ; p>.99).

There was a statistically significant intra-surgeon difference in ΔInc for surgeons B and C. (A, p = 0.19 ; B, p < 0.001 ; C, p = .007 ; D, p = 0.62) (Fig. 4) but not in ΔVer (A, p = 0.23 ; B, p = 0.38 ; C, p > 0.99 ; D, p = 0.26) (Fig. 5).

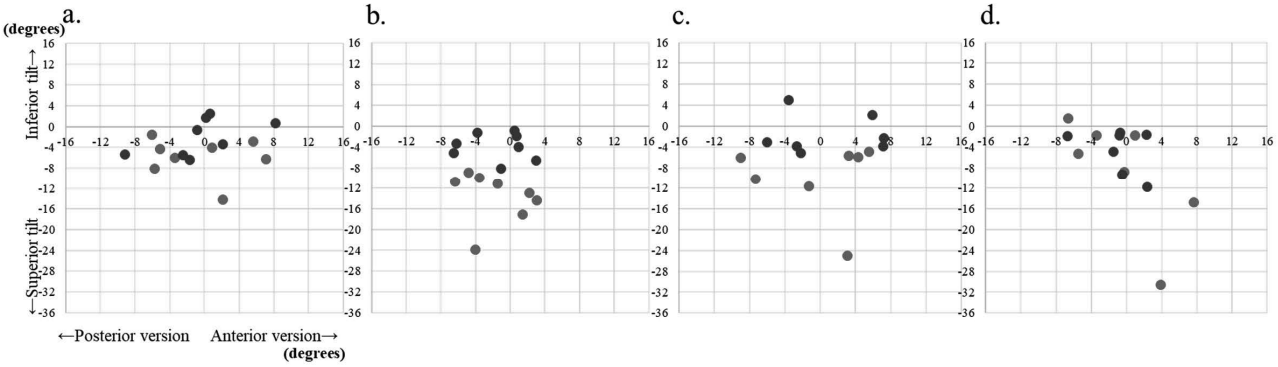

Figure 3. Distribution of baseplate positions. Surgeon A (a), surgeon B (b), surgeon C (c), and surgeon D (d). The red markers indicate use of the conventional freehand method, and the blue markers indicate use of the PSI method. The tilt angle distribution tended to superior site, especially with the conventional method.

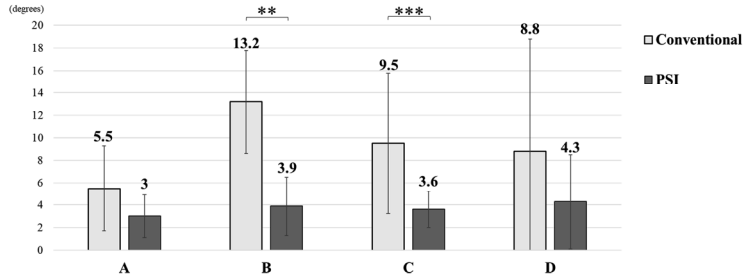

Figure 4. Comparison of absolute deviation in inclination from the preoperative plan between the conventional method and the PSI method. There was a statistically significant intra-surgeon difference in surgeons B and C. **p < 0.01, ***p < 0.001. PSI, patient-specific instrumentation

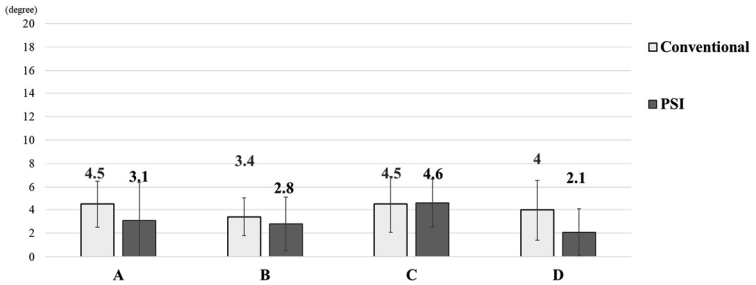

Figure 5. Comparison of absolute deviation in version from the preoperative plan between the conventional method and the PSI method. There was no statistically significant intra-surgeon difference. PSI, patient-specific instrumentation

DISCUSSION

The results of this study confirm that surgeon experience affects the accuracy of baseplate implantation when using PSI, particularly when surgeons are less experienced.

A number of studies have investigated the effects of PSI (11, 13, 15-19). In one of these studies, Throckmorton *et al*. compared the accuracy of implant placement in 70 cadaveric shoulder specimens by 5 surgeons with varying levels of experience and found that positioning was more accurate using PSI than when using standard instrumentation (11). Lau and Keith also reported that the use of PSI was beneficial in 11 consecutive cases that underwent total shoulder arthroplasty (16). In our present study, the mean ΔInc was 3.7° when using the PSI method, which is within the error range of 0.1° to 4° for PSI demonstrated in a systematic review. (1) The distributions of the tilt was tended to superior site described as Figure 3. The significant improvement shown in Figure 4 indicates the usefulness of PSI. However, we found no statistically significant inter-surgeon difference in ΔVer even with conventional method. The analysis about outlier cases also couldn't demonstrate difference statistically. When using the PSI method, the mean ΔVer was 3.2°, which does not exceed the value reported by the systematic review (15). These findings indicate that the accuracy of version may be less affected by surgeon experience. Based on the Friedman line, the scapular morphology is anatomically closer to neutral in version than inclination (20, 21), so it may be possible to insert neutral position even with the conventional guide.

Several studies have investigated the effect of surgeon experience on the outcomes of arthroplasty (22, 23). Cullen *et al*. reported that revision-free survival in hip surgery was greater for high-volume surgeons (22), and Kraus *et al*. found that complex procedures completed by less experienced surgeons may result in longer operation times, more blood loss, and more early reoperations (23). Our finding that the conventional method of implantation is less accurate in the hands of less experienced surgeons underscores the importance of surgeon experience. In our study, there was no significant difference in the accuracy of implant placement according to whether PSI or standard instrumentation was used for surgeon A, who was highly experienced. It is also interesting to note that no differences were observed for surgeon D, suggesting that a minimum level of skill may be required to realize the benefits of PSI.

The main limitations of this study were the small number of cases and the focus on mild glenoid erosion. As the number of cases increases, it has the possibility that a significant difference in mean error is observed even in surgeon D. We cannot rule out the possibility that better results for PSI, including for version, could have been achieved by inclusion of cases with more severe glenoid erosion. Second, the accuracy of implant placement may have been affected by the materials used to construct the models. Third, there is no soft tissue tension, deltoid, humerus, or other anatomical landmarks in this study design.

CONCLUSION

PSI ensured the accuracy of baseplate implantation in RSA regardless of a certain amount of surgeon's experience. Implantation accuracy was more impacted when the surgeon was less experienced.

SOURCE OF SUPPORT

None.

DISCLAIMER

None.

ETHICAL APPROVAL

The study was approved by the Institutional Review Board of NHO Kochi National Hospital (approval number R3-1).

LEVEL OF EVIDENCE

Level IV : Basic Science Surgical Technique

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