




Anatomic and Reverse Stemless Shoulder Arthroplasty: Functional and Radiological Evaluation

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Abstract

Background: Stemless shoulder arthroplasty was developed to restore the glenohumeral centre of rotation without violation of the humeral shaft. It allows the preservation of humeral bone stock. Complications related to stem malalignment and periprosthetic fractures can be avoided.

Patient and methods: This is a prospective observational study that reports outcomes of 46 patients who received stemless shoulder arthroplasty “Comprehensive Nano implant®.” The series includes Group (A): 30 anatomic and one hemiarthroplasty. Group (B): 15 reverse stemless replacement. Functional outcomes were assessed by visual analog score (VAS), satisfaction, range motion, Constant score, and American Shoulder and Elbow Score (ASES).

Results: The mean follow-up was 40.4 ± 12 months (range, 24 months to 60 months). Group (A): VAS and satisfaction improved by 5.3 and 67.5 points respectively. Constant score significantly improved from 28.5 ± 14.5 to 62.5 ± 23 $P < 0.001$. The radiological assessment showed the mean centre of rotation (COR) deviation was 2.8 ± 1.9 mm. 27% of patients have COR discrepancy of more than 4 mm. In Group (B), patients reported a significant improvement in VAS, Satisfaction, and ASES $P = 0.002, 0.002, \text{ and } 0.003$, respectively. Complications include shoulder pain with progressive loss of movements, aseptic loosening early subscapularis rupture, glenohumeral dislocations, and humeral component migration.

Conclusion: Anatomic Stemless total shoulder arthroplasty offers acceptable results and improvement of overall functional outcomes.

Keywords

shoulder, arthroplasty, stemless, anatomic, reverse

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Introduction and Review of Literature

Stemless shoulder arthroplasty was first introduced in 2004 as an evolving alternative to the conventional stemmed prosthesis.¹ It gained popularity among surgeons, and numbers have continued to escalate in the last few years. According to the England National joint registry 2020, 888 (12.2% of total shoulder arthroplasty) anatomic stemless shoulder arthroplasty had been performed in 2019 compared to 135 (5.3% of total shoulder arthroplasty) in 2012.² Stemless shoulder implants provide a solution for patients with humeral deformities who need a shoulder replacement while preserving bone stock for future revision surgery.³ It offers easier and time-saving revisions compared with reported difficulties of stem extraction, particularly in cemented stemmed prostheses.⁴

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Biomechanical advantages of canal sparing humeral prostheses are maintaining the glenohumeral joint kinematics and neutralizing the posteromedial offset without breaching the humeral medulla.⁵ It has been found that changing the postoperative kinematics by only 4–5 mm will reduce the arc of movement and affect the implant survival.⁶ Glenohumeral joint overstuffing is caused by changing mechanics that force the humeral head to early translation, leading to edge loading at the glenoid.⁷ In contrast, a small-sized head can lead to early impingement between the greater tuberosity and acromion, which also can cause a reduction in shoulder function.⁸

Negels et al found that 9% of stemmed shoulder prostheses have a significant cortical thinning in the proximal lateral region after an average of 5.3 years postoperatively. There was also a significant proportional relationship between the stem size and the degree of stress shielding in these six patients.⁹ N. Razfar et al compared the relation between stem length and load transfer. They reported that reducing the humeral stem length creates more stress on the surrounding proximal humeral bone than stemmed implants. Therefore this reduces the burden of stress shielding on the proximal humerus and decreases the risks of intraoperative fractures in revision surgeries.¹⁰

Fixation of canal sparing humeral components relies heavily on implanting the humeral component in an adequate quality cancellous bone which provides initial stability until complete osteointegration. This differs from conventional designs that achieve stability by press-fitting through the cortical medullary canal independent from metaphyseal bone quality. P. Favre et al concluded that metaphyseal bone mass and delayed postoperative loading enhances stability by minimizing micromotion.¹¹

This study reports the functional and radiological outcomes of a single implant of stemless shoulder arthroplasty. The study also highlights major intraoperative and postoperative incidents related to the surgery.

Patient and Methods

Design

This prospective observational case series was conducted from 2013 to early 2017. All procedures were performed in

a single centre by the senior authors. All patients gave formal consent to be recruited for this research: “Comprehensive Nano[®] EU post-market data collection.” Protocol number: ORTHO.CR.GE2.13.

All patients consented to the possibility of utilizing stemmed humeral components in cases of humeral component instability due to diminished bone quality.

The inclusion criteria include patients with non-inflammatory degenerative arthritis, rheumatoid arthritis, correction of functional deformity, revision of failed resurfacing devices, and rotator cuff arthropathy. Patients with active infection and insufficient bone stock, such as significant (>1 cm) multiple subchondral bone cysts) are excluded. Intraoperative bone quality was assessed following the thumb technique as described by Churchill et al¹²

54 patients were consented for a canal sparing shoulder replacement. It was not possible to be used in six patients who were excluded from the study. The first patient was a revision of a Copeland resurfacing. After the implant removal, the residual bone stock was not enough to support the humeral trial component. On the second patient, intraoperatively, the bone quality was poor to maintain the trial implant stability. The glenohumeral joint was overstuffing in the remaining four patients after trial reduction. The planned procedure -of using humeral component without a stem- for all these patients was abandoned and stemmed prostheses were implanted.

Out of the remaining 47 patients (48 shoulders), one patient died for a cause not related to surgery. Another patient did not attend for any postoperative follow-up despite the clinical records showing the patient attended the hospital for other clinical reasons. These two patients were excluded. Hence, by the final follow-up, we report the results for 46 shoulders.

46 stemless shoulder replacements were performed for 45 patients. There were 24 males and 21 females. 21 patients had the shoulder replacement in the dominant upper limb. The mean body mass index was $28.41 \pm 6.5 \text{ kg/m}^2$. All demographic data are included in Table 1.

The mean follow-up was 40.4 ± 12 months (range, 24 months to 60 months).

All patients received the same implant; Comprehensive Nano[®] stemless prosthesis (Zimmer-Biomet, Indiana, USA).

Table 1. Demographic data for Group (A), (B)

	Group A	Group B
Number of patients	31	15
Age	56 ± 12	70 ± 7
Dominant involvement	15	5
BMI	$28 \pm \pm$	28 ± 4
Operative timing	98 ± 21	88 ± 17
Blood loss	163 ± 62	184 ± 68
Hospital stay	3 ± 2	2 ± 1
Follow-Up Period	40 ± 12 months	27 ± 6 months

Preoperative Clinical and Radiological Assessment

Preoperatively, Detailed patient history, including social habit and occupation. The assessment consisted of patient completion of self-assessment questionnaires (subjective scores) of pain intensity according to the visual analog scale (VAS). The score is based on a numeric ranking from 0 to 10, zero is no pain, and 10 is severe pain. American Shoulder and Elbow Score (ASES)¹³ and Single assessment numeric evaluation (SANE) to report overall satisfaction with shoulder function was noted out of 100. Objective

shoulder scores Constant Score (CS) was recorded. Active range of motion measurements forward flexion and lateral elevation in degrees, external rotation. The highest anatomic landmark assessed internal rotation. Arm strength using a spring balance system was measured. Patients were scored during the preoperative visit after consenting for the surgical procedure and the recruitment.

Clinical, x-ray, and MRI scan assessments for the integrity of rotator cuff tendons were performed for all patients to determine the type of glenohumeral articulation (anatomic/reverse).

All patients had a CT scan for preoperative planning to assess glenoid bone stock, glenoid version, length of the scapular vault, and any glenoid and humeral bone cysts. Intraoperatively, glenoid patient-specific instruments (Signature guide glenoid[®], Zimmer-Biomet, USA) were utilized in 41 patients. A specific CT protocol of 250 mm field of view or smallest to include all bony anatomy of the scapula and adjacent humerus with a slice thickness of 0.625 mm or less in the axial plane was followed.

Surgical Technique

All patients received general anaesthesia with interscalene block. Patients were positioned on a beach chair with a secured head. Prophylactic antibiotics (Cefuroxime and Teicoplanin) were given at the induction of anaesthesia. A standard deltopectoral approach with subscapularis peel and long head of biceps tenodesis was performed for all patients.

In stemless shoulders, three critical points to consider. The first point is to preserve proximal humerus cancellous bone during humeral head resection to provide adequate support and stability for the humeral anchor. The second tip was to use of designed cutting angle at 135 degrees which is the midrange of humeral inclination variation (125 to 145).⁸ This cutting angle equalizes both varus and valgus head inclination. In our study, the mean of the humeral inclination cutting angle was 143 degrees. The third and the most important was choosing the appropriate prosthetic humeral head sizer and broach. This is achieved by using the optimal size of the resection guide to reproduce patients' own anatomy; this will avoid overstuffing. The aims of considering these measures are to avoid breaching the humeral cortex by the broach and humeral component and restore the anatomic head thickness, which is essential to recreate glenohumeral kinematics.

In the reversed shoulder, the main concern is to attain 135 degrees inclination angle of proximal humerus osteotomy to avoid glenoid notching, subacromial impingement, and increased rotational movements.¹⁴

Patient-specific instrumentation (PSI) was utilized in all patients except one patient as PSI was not available, and a freehand guide was used. The placement of the glenoid jig determines the type of glenohumeral articulation. In

anatomic shoulders, the jig position is perpendicular to the neutral axis of the glenoid surface, while, in reversed shoulder arthroplasty jig position was tilted inferiorly by 10 degrees. In anatomic replacement, cemented all-polyethylene glenoid component with a central metal peg was used for all anatomic patients. In reversed articulations, a non-cemented baseplate was used for all patients with an inferior offset to avoid scapular notching.

Subscapularis was repaired and reattached to the lesser tuberosity in all anatomic and reversed arthroplasty.

Postoperatively, all patients received VTE prophylaxis for two weeks. Shoulders were immobilized in an arm-sling for four weeks, and external rotation was avoided for six weeks.

Physiotherapy started from day one postoperatively, concentrating mainly on hand and elbow movements. From the second week, gradual passive shoulder exercises started, assisted active movements, and avoided excessive shoulder loading. By the sixth week, patients were encouraged to gradually increase the frequency of shoulder exercises, loads, and range of motion.

Postoperative Follow-up

Patients were assessed clinically after two weeks postoperatively for a wound check and any early postoperative complications. Patients were reviewed at six weeks, 3, 6, 12 months, and then annually for follow-up using the same preoperative protocol.

Radiological Follow-up

On day one postoperatively, the shoulder anteroposterior (AP) radiograph was assessed for any serious complications. Postoperative radiographs of both AP and axillary views were evaluated at six weeks, three, six months, and then annually. The radiographic assessment protocol for the Verso shoulder replacement was followed for any zonal radiolucency, osteolysis, or loosening signs.¹⁵ Component migration, subsidence, glenohumeral integrity, any notable proximal humeral migration, and bony fractures were evaluated radiologically.

In anatomical replacements, preoperative and postoperative studies were reviewed by the first author to compare differences in glenohumeral geometry by measuring neck-shaft angle (NSA), lateral glenohumeral offset (LGHO), and deviation of the centre of rotation (COR) following best-fit circle as described by Youderian et al.¹⁶ A deviation of 4 mm from anatomical COR is considered of clinical relevance.

In the reverse shoulder replacements, scapular notching was assessed as described by Sirveaux-Nerot et al.¹⁷

The senior authors reviewed all radiographic studies. There was controversy about radiological signs of humeral component loosening in five patients. The images were

Table 2. summary of group (A) results of anatomic glenohumeral articulation and stemless hemiarthroplasty.

	Mean	Median	Min.	Max.	Gain Improved "mean"	P-Value
Pain						
Preop	7.3 ± 2	8.88	0	10	5.3	<0.001
Final FU	2.0 ± 3	0	0	8		
SANE						
Preop	14.5 ± 19	0.00	0	60	67.5	<0.001
Final FU	82 ± 25	90	20	100		
CSS						
Preop	28.5 ± 14.5	26	10	61	34	<0.001
Final FU	62.5 ± 23	67	18	91		
Arm St.						
Preop	5 ± 4	2	0	15	6	<0.001
Final FU	11 ± 7	11	0	25		
ADL						
Preop	7.5 ± 4	6	2	18	8	<0.001
Final FU	15.5 ± 5	17	6	20		
ASES						
Preop	23.5 ± 14.2	20	2	75	47.5	<0.001
Final FU	71 ± 28	82	0	100		
FF						
Preop	88 ± 40	90	30	150	48	<0.001
Final FU	136 ± 40	140	45	180		
LE						
Preop	80 ± 42	77	20	150	35	<0.001
Final FU	115 ± 40	120	30	170		
ER						
Preop	29 ± 23	25	0	90	31	0.079
Final FU	60 ± 20	60	20	90		

discussed in multi-disciplinary team MDT meetings with senior surgeons and the radiology team.

Statistical Analysis

A spreadsheet was entered into Excel (Microsoft, Redmond, WA, USA). Data were managed using SPSS software (version 24.0; SPSS Inc., Chicago, IL, USA) for statistical and data analysis. Quantitative data were expressed as the mean and standard deviation (SD). Qualitative data were expressed as frequency and percentage. Data were analyzed using nonparametric tests. Specifically, the Wilcoxon test measures the preoperative to postoperative improvement. Mann-Whitney test was used to identify differences in preoperative, and postoperative findings between the two groups. Kruskal-Wallis test was used to analyse differences between Preoperative, and postoperative between more than two groups. P-value <0.05 was set as a statistically significant reference.

Results

Glenohumeral osteoarthritis was the main indication for shoulder replacement in 36 patients (78%), inflammatory arthritis 13%, rotator cuff arthropathy 5%, irreparable

massive rotator cuff tear 2%, and traumatic arthritis and instability 2%.

The Comprehensive Nano[®] stemless prosthesis (Zimmer-Biomet, Indiana, USA) was utilized in all patients. Three different types of glenohumeral articulation were used depending on the integrity of rotator cuff tendons; 30 (65%) anatomic glenohumeral articulation, 15 (32%) reverse shoulder, and one hemiarthroplasty (3%) were implanted.

Operative time was calculated from the theatre management system between sign-in and sign-out time. The mean operative timing was 95 min ± 20 SD. Estimated blood loss was reported to the number and weight of the utilized swabs. The mean estimated blood loss was 170ml ± 64 SD. The mean of postoperative hospital stay was three days ± two SD.

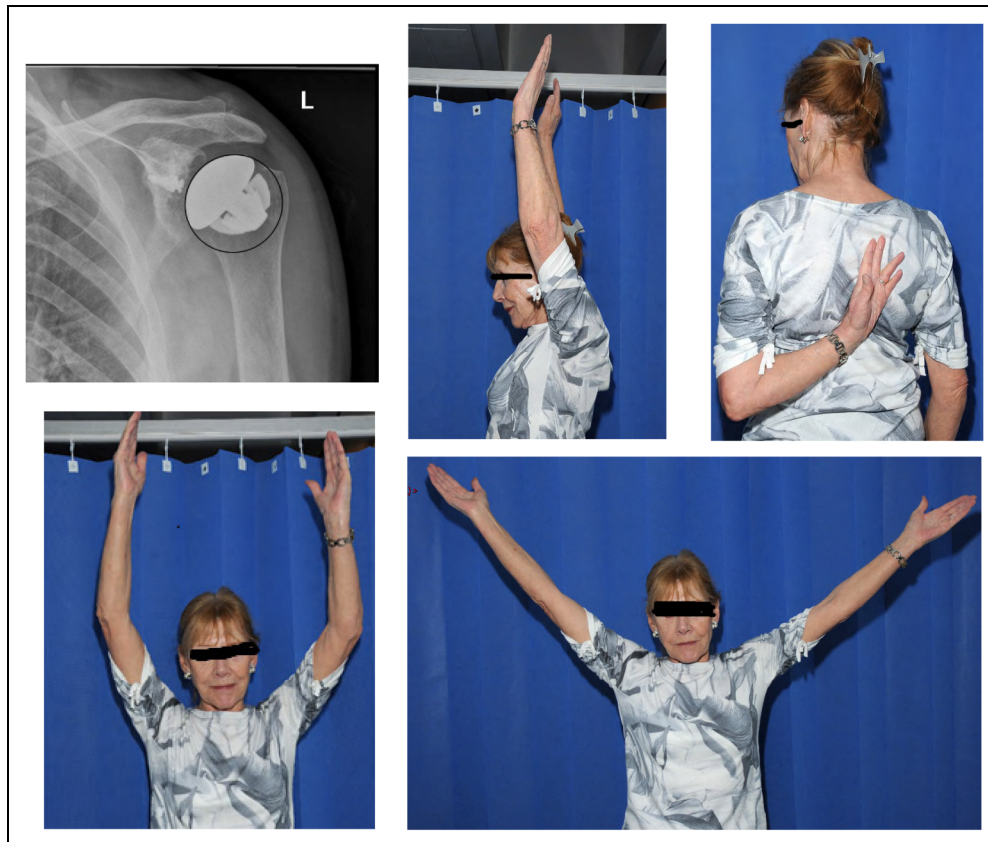
Patients were grouped into (A) and (B) according to the type of glenohumeral articulation. Group A: 31 (68%) patients received anatomic shoulder articulation and hemiarthroplasty prosthesis. Group B includes 15 (32%) patients who had reverse glenohumeral configuration.

Postoperative Functional Results

Age, gender, and the dominant side affected were not statistically different in all improved parameters.

Table 3. group (A) internal rotation

	Preoperative Numbers	Percent	Postoperative Number	Percent
Thigh	6	21.4%	4	14.3%
Buttock	10	35.7%	5	17.9%
Sacroiliac	6	21.7%	2	7.1%
L3	5	17.9%	9	32.2%
D12	1	3.6%	6	21.4%
D6	0	0%	2	7.1%

**Figure 1.** Radiograph and clinical photos of postoperative functional results and ROM after anatomic stemless shoulder arthroplasty.

In group (A) Anatomic shoulder replacement:

All tested subjective parameters are summarised in Tables 2 and 3. There was a significant improvement when comparing preoperative to final follow-up except for the shoulder stability Figure 1.

Changes in postoperative COR did not show any statistical significance in the functional scores.

In Group (B), reversed shoulder arthroplasty:

VAS, SANE, and ASES showed significant improvement in the last follow-up visit $P = 0.002$, 0.002 , and 0.003 , respectively. In the last follow-up, CSS showed significant improvement from 30 points to reaching 60 ± 18 on the last FU visit $P = 0.004$. Means of range of movement arm

strength and ADL have been significantly improved, as summarised in Tables 4 and 5.

Postoperatively, no patient experienced any nerve or vascular complications. No infection or wound healing problems were reported until the last follow-up.

In the comparison between the two groups -according to the type of glenohumeral articulation- there was no statistical difference in the improvement of the scores.

Radiological Assessment

On the last follow-up, Radiolucency around the humeral component was identified in one patient 18 months

Table 4. Summary of group (B) results of reverse stemless glenohumeral articulation.

	Mean	Median	Min.	Max.	Gain Improved "mean"	P-Value
Pain						
Preop	8.0 ± 1.8	8.0	4.0	10.0	6.8	0.002
Final FU	1.2 ± 2.1	00.0	00.0	7.0		
SANE						
Preop	10 ± 20	0.00	00.0	70	73	0.002
Final FU	83 ± 22	100	50	100		
CSS						
Preop	30 ± 18	25	8	64	30	0.004
Final FU	60 ± 18	66	29	96		
ASES						
Preop	28 ± 16	22	00.0	65	48	0.003
Final FU	76 ± 20	80	45	100		
FF						
Preop	82 ± 43	90	20	60	28	0.179
Final FU	110 ± 36	80	60	170		
LE						
Preop	77 ± 35	80	20	60	23	0.136
Final FU	100 ± 33	90	60	160		
ER						
Preop	15 ± 15	10	00.0	45	30	0.008
Final FU	45 ± 25	45	00.0	90		
Arm St.						
Preop	7.5 ± 6		00.0	25	4.5	0.091
Final FU	12 ± 6	11	5	25		
ADL						
Preop	6 ± 4	6	2	14	9	0.002
Final FU	15 ± 4	16	8	20		

Table 5. Group (B) internal rotation

	Preoperative Number	Percent	Postoperative Number	Percent
Thigh	4	28.6%	1	7.1%
Buttock	3	21.4%	5	35.7%
Sacroiliac	4	28.6%	6	42.9%
L3	2	14.3%	1	7.1%
D9	1	7.1%	1	7.1%

postoperative. A CT scan confirmed loosening. No radiolucency or loosening signs were detected at glenoid sides for any patients until the last follow-up.

For Group (A): the mean of the postoperative centre of rotation (COR) deviation compared to patients' anatomy was 2.8 ± 1.9 mm. Eight shoulders (27%) showed COR discrepancy of more than 4 mm Figures 2 and 3. Five out of these eight shoulders exhibit high valgus neck-shaft angle NSA (median of 145) in the preoperative radiographs. Unified 135 degrees humeral neck angle osteotomy was performed. Transforming this valgus NSA angle into a more varus position causes overstuffing of the glenohumeral joint. These patients had poor functional outcomes and a higher pain level on VAS. Glenohumeral geometry changes are concluded in Table 6.

For Group (B): No glenoid notching was detected for any patient.

Complications

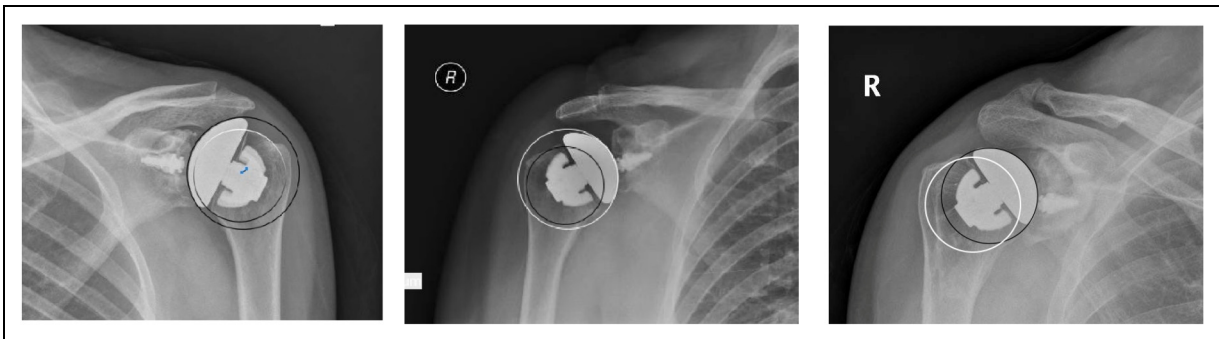
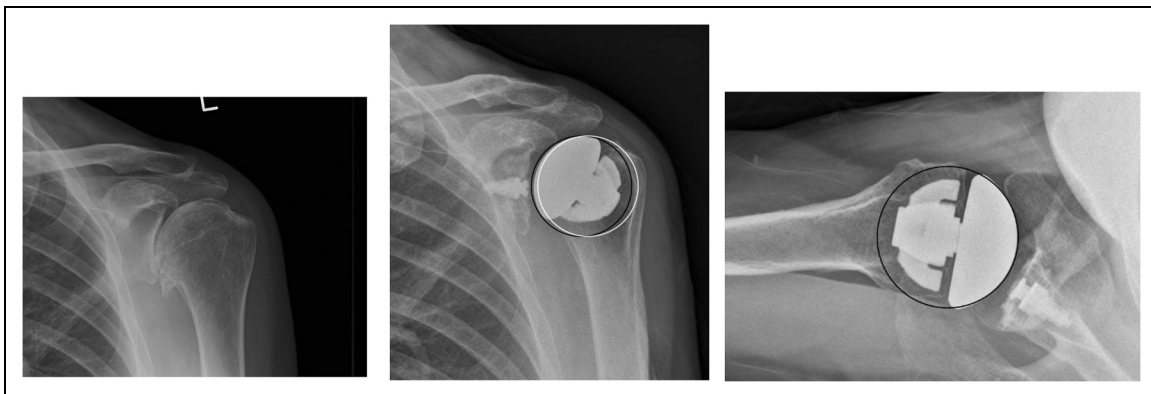
In group (A), out of 31 patients, three patients (9.5%) presented with shoulder pain with progressive limited range of motion. Infection was excluded. In the first patient, a CT scan identified glenoid malposition. The second patient presented with anterior shoulder pain related to the biceps tenodesis site; open exploration and tenotomy was performed. Six months post-tenotomy, pain, and other objective scores noticeably improved. A third patient who had hemiarthroplasty presented in the second-year follow-up with progressive shoulder pain and limited range of movements. Radiographs showed glenoid wear. Ultrasound scans

Table 6. pre, postoperative measures in NSA, LGHO

	Mean	Median	Minimum	Maximum
Neck Shaft Angle (NSA)				
Preoperative	137 ± 9	136	128	146
postoperative	128 ± 14	129	124	138
lateral glenohumeral offset (LGHO)				
Preoperative	67.3 ± 50	76.6	50	90
Postoperative	74.4 ± 60	73	60	92

Table 7. Summary of causes of revision.

Type of Glenohumeral articulation	Cause	Time to revision / decision to revision
Hemiarthroplasty	Overstuffed, massive irreparable rotator cuff tear 3 years postoperative	36 months
Anatomic humeral design	Humeral component aseptic loosening	18 months
Anatomic humeral design	Shoulder pain, diagnosed intraoperatively with loosening	24 months
Anatomic humeral design	Traumatic dislocation and periprosthetic humeral fracture	20 months
Anatomic humeral design	Traumatic periprosthetic humeral fracture	30 months
Anatomic humeral design	Subscapularis rupture	18 months
Reversed Humeral design	2 patients with immediate humeral component migration	3 days
Reversed Humeral design	Complicated with CVS, dislocation and required constrained articulation	24 months
Reversed Humeral design	Traumatic periprosthetic fracture	3 months

**Figure 2.** Radiographs show best-fit circle and the deviation of the centre of rotation (COR) after Nano stemless shoulder replacement. Deviation of >4mm. reflected on the poor functional outcomes with a strong statistical correlation for revision surgery.**Figure 3.** Preoperative and postoperative radiographs with 2 mm COR deviation on AP and no deviation on the lateral view, this patient had the best functional results for a range of movements, arm strength.

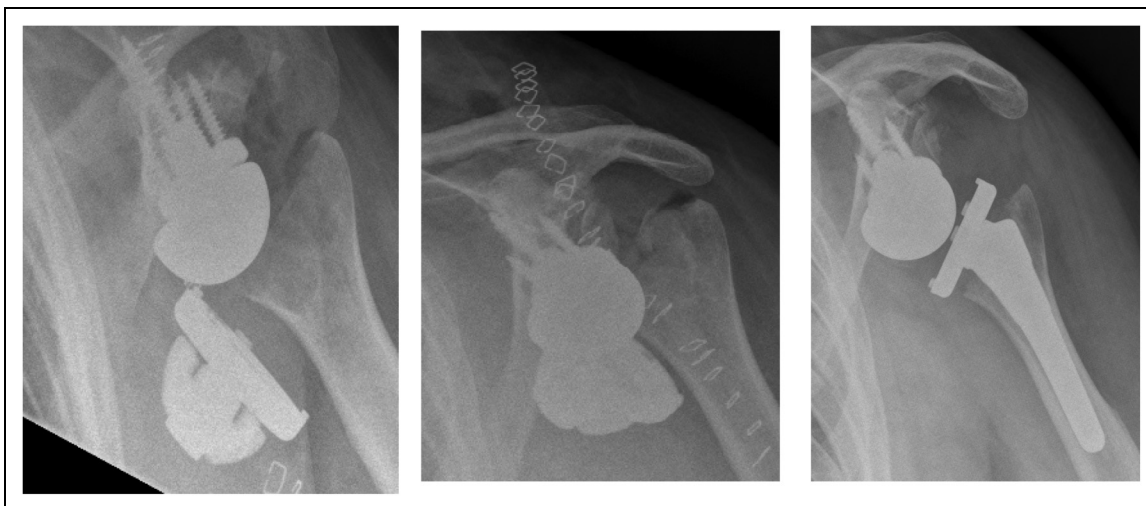


Figure 4. Radiograph showed immediate postoperative humeral component migration after reverse configuration of stemless prosthesis. This required revision with a stemmed implant.

revealed torn rotator cuff tendons. This patient is waiting for revision surgery.

Aseptic loosening and lack of osteointegration of the humeral anchor were diagnosed in two (6%) patients. In the first patient, radiolucency around the humeral component was confirmed. The prosthesis was subsequently revised. Intraoperatively, the humeral part was loose and extracted easily. The second patient presented with unexplained shoulder pain and was diagnosed intraoperatively with a loose humeral component. These two shoulders were revised into stemmed implants. Intraoperative cultures and histology did not reveal any infection.

Two patients (6%) had glenohumeral dislocation after traumatic incidents. The humeral component was revised to a stemmed prosthesis. The other patient was managed with closed reduction and continued to have a limited range of movements. Ultrasound scans showed a massive irreparable rotator cuff tear. This patient is waiting for revision to stemmed reversed arthroplasty.

Early postoperative subscapularis rupture was diagnosed in one patient three months postoperatively. Open subscapularis repair was performed. No significant clinical improvement was reported post-repair. x-rays showed anterior subluxation of the glenohumeral articulation. This patient had a stemmed reversed shoulder arthroplasty.

In group (B) reversed shoulder arthroplasty. Out of 15 shoulders; two patients (13%) had immediate postoperative humeral component migration despite having satisfactory component stability intraoperatively Figure 4.

One patient (6%) had a cerebrovascular stroke two years postoperatively which affected the ipsilateral side of the shoulder replacement. This stroke affected the stability of the reversed prosthesis. This shoulder was revised by stemmed constrained linked glenohumeral articulation to secure stability.

One patient (6%) had a traumatic incident 3 months postoperatively complicated with proximal humeral fracture which affects the component stability. The humeral components were revised by using a stem.

Discussion

Stemless shoulder arthroplasty was promoted as being a bone preserving procedure. It avoids stem-related complications and gains benefits of the humeral resurfacing procedures in preserving glenohumeral kinematics. Comprehensive Nano[®] stemless arthroplasty was released in 2013 as a development of the old TESS[®] implant. It has a collarless convertible humeral component that allows both anatomic and reversed glenohumeral articulation. The six-armed humeral component provides a large surface area to integrate with the metaphyseal bone.

Even though mid-term functional outcomes of stemless shoulder implants are available in the literature,^{18–20} this will be the first report of Comprehensive Nano[®] prosthesis outcomes with a minimum follow-up of two years.

In this series, the mean age at surgery was 60 years \pm 13 (range, 33–82 years)

Group (A): In the four out of the six patients excluded from the study. Intraoperatively, the glenohumeral joint was tight and overstuffed after a trial reduction. It was essential to resect more bone from the proximal humeral metaphysis. This jeopardized the humeral component stability due to lack of metaphyseal bone support. We believed that patients with high valgus NSA of > 145 are more liable to have glenohumeral overstuffing. In these patients, the only available option is to do lower humeral osteotomy and use a stemmed implant as using a smaller head size will lead to an early impingement of the greater tuberosity against the acromion which can cause a reduction in shoulder function as noted

by Peal.⁸ Another option is to use patient-specific instrumentations for humeral osteotomy, which is still under experiment. It is recommended that a detailed discussion with patients preoperatively at the consent time as there is still a possibility to use stemmed implants. A conventional stemmed kit should always be available as a backup plan.

The first patient included in this series complained of persistent shoulder pain. That was investigated with CT scan that showed glenoid component malposition. Freehand glenoid guide was used for glenoid placement in this patient. We changed our practice and PSI was utilised for all other patients.

Von Engelhardt LV et al studied whether the anatomic stemless shoulders replicate individual anatomy. They reported that COR deviation was statistically insignificant but 14% had poor functional outcomes due to insufficient humeral neck osteotomy, leading to overstuffing.⁵ In this series, we report a COR discrepancy was found in 19%. This is reflected on two patients with poor functional results and presented later with a tear of the subscapularis rotator cuff tendon. Intraoperatively, the prosthesis edge was over-hanged anteriorly to impinge against the tendon. This required revision into stemmed reversed articulation. Our results show a strong statistical correlation between COR deviation ≥ 4 mm and revision surgery $P = 0.001$. Preoperative templating is an important step to predict the humeral component position.

Our results are compared to outcomes of what is reported in the literature.^{20, 21} We report a significant improvement in the functional results in CCS and ASES as means of gained improvement in points are 34 and 47.5, respectively. Activities of daily living improved by eight points. Huguet et al studied the improvement of functional results after anatomic stemless shoulder arthroplasty on 70 patients (72 shoulders). patients gained 49 degrees for forward flexion and 20 degrees for external rotation. Constant score improved from 29.6 to 75 postoperatively. the overall complication rate was 10% with five patients had intraoperative humeral cracks with no impact of prosthesis stability.²⁰ Habermeyer et al reported medium-term functional results of anatomic TESS[®] shoulder replacement on 78 patients. Patients gained 19.2 points in CSS which improved from 45.8 in the preoperative to 65 postoperatively. CSS improvement has been reflected on the patient's daily activities which also escalated from 9.9 to 15.5.²¹

Anatomic Comprehensive Nano[®] was promoted as convertible to a reverse configuration in revision surgeries. In our series, four shoulders were revised into a stemmed prosthesis. Initially, it was planned to convert the glenoid component with retaining the humeral side. In reality, that was utterly impractical for two reasons: A) increased the deltoid muscle tension and tightness, required resection of more bone of the humeral metaphysis after component extraction. B) humeral component was loose and easily extracted during the revision surgery.

In Group (B):

Ballas et al reported functional results of 56 reversed configurations of TESS[®]. CS improved from 29 ± 8 to 62 ± 12 . This is reflected on ADL as it increased by 9 points. Patients gained 61 degrees of active forward flexion as it improved from 79 ± 28 to 170 ± 17 .¹⁸ In our study, CS increased by 30 points from 30 ± 18 to 60 ± 18 . ADL gained 9 points. FF gained 48 degrees.

In our study, two patients with a reverse glenohumeral articulation were complicated by immediate postoperative humeral component migration despite being stable intraoperatively. The original pathology for the two patients was rotator cuff arthropathy. Ballas et al experienced glenoid component disassembly that required revision of TESS[®] implant in four patients (7%).¹⁸ Kadum et al reported humeral component migration of the same design in 12.5% where revised on the third day postoperatively.²² It is worth mentioning that reversed configuration was recalled by the medicines and healthcare products regulatory agency (MHRA-UK) in 2017 due to early complications and loosening.²³ The collected data by the manufacturer indicates that the Humeral Component of Comprehensive Nano[®] did not meet the expected performance rate (EPR) when used in the reverse configuration. Therefore, the manufacturer has changed the indications as this must no longer be used in the reverse configuration. The component is still used in the anatomic configuration.

In this series, 16% of stemless anatomic glenohumeral configurations required revisions. 20% of stemless reversed arthroplasty had revision surgery. This is summarised in Table 7. In both groups, the overall revisions causes related to the humeral component complications are found only in 13% (6 shoulders/46). The other reasons are patient incidents related, such as trauma and CVA. Comprehensive[®] mini stem length (83 mm) was used for all revision cases Figure 4. Stemless Nano is a bone preserving implant that can still be revised easily to a short primary stem. In normal occasions where the stem is utilized, longer stems are usually required for revision cases in addition to the burdens of old stem extraction.

The limitations of this study are the heterogeneous groups of anatomic and reverse articulations are not comparable. A larger sample is needed to be included to support the results. Another limitation is the mean follow-up is 40 months. Although this is comparable to those published in the literature, a longer follow-up period is necessary to spot complications and survivorship. It is also important to report another comparison study between stemmed and stemless shoulder arthroplasty.

Conclusion

NANO stemless shoulder arthroplasty has provided acceptable short and mid-term functional and radiological outcomes. Patients with high NSA > 145 have poor outcomes

after stemless arthroplasty. A high correlation between post-operative COR deviation ≥ 4 mm and revision surgery. Reversed stemless NANO arthroplasty is associated with early complications, and a secured design of stemless reverse prosthesis is required.




Declaration of Conflicting Interests

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