ORIGINAL ARTICLE

Clinical Outcomes and Complications Rates at Mid-term Follow-Up of Cementless Reverse Shoulder Arthroplasty

Résultats cliniques et taux de complications à moyen terme des prothèses inversées de l'épaule à tige non cimentée

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Abstract

Introduction-Aim: Reverse shoulder arthroplasty (RSA) is a valid option for several degenerative conditions of the shoulder. This study aimed to analyze mid-term functional outcomes and complications rates of cementless stem.

Methods: From January 2016 to December 2020, retrospective review of cementless RSA for degenerative conditions was established. Clinical outcomes were assessed using visual analog scale (VAS), University of California Los Angeles (UCLA) score, Constant score and range of motion (ROM). Radiographic findings were evaluated during follow-up. Complications rates was reported.

Results: At mid-term follow up of 39 months, 40 shoulders were included with sex-ratio= 0.53 Mean age was 67.7 years (60 -82). VAS score improved from 5.0 to 2.2 (p = 0.014). UCLA score increased from 17.2 to 25.7 (p = 0.002) and Constant score improved from 31.89 to 70.2 (p < 0.001). Active anterior elevation, abduction, and external rotation showed enhancement respectively 80° to 141.2°, 71° to 132.2° and 5.8° to 19.7° (p values < <0.0001). The mean calcar filling ratio was 0.86 (0.32 – 1.17 +/- 0.22). The mean proximal and distal filling ratios were 0.62 (0.48 – 0.73 +/- 0.06) and 0.56 (0.36 – 0.71 +/- 0.09) respectively. The overall rate of postoperative complications was 22.5%.

Conclusion: Cementless stem improve functional outcomes at mid-term follow up. Stems were correctly aligned with the humeral axis and canal filling ratios were <0.7 in all cases. Stress-shielding was slightly higher without impact on clinical outcomes.

Key words: Shoulder, Arthroplasty, Stem, Fixation, Outcomes

Résumé

Introduction-Objectif: La prothèse inversée de l'épaule (RSA) est une option valable pour plusieurs pathologies dégénératives de l'épaule. Cette étude visait à analyser les résultats fonctionnels à moyen terme et le taux de complications de la tige non cimentée.

Méthodes: Il s'agit d'une revue rétrospective des prothèses inversées à tige non cimentées posées pour des affections dégénératives. Les résultats cliniques étaient évalués selon l'échelle visuelle analogique (EVA), score de l'Université de Californie à Los Angeles (UCLA), score de Constant et les amplitudes articulaires. Les résultats radiographiques étaient évalués au cours du suivi.

Résultats: Au recul moyen de 39 mois, 40 épaules ont été incluses. L'âge moyen était de 67,7 ans. Le score EVA était amélioré de 5,0 à 2,2 (p = 0,014). Le score UCLA est passé de 17,2 à 25,7 (p = 0,002) et le score de Constant s'est amélioré de 31,89 à 70,2 (p < 0,001). L'élévation antérieure active, l'abduction et la rotation externe présentaient une amélioration respectivement de 80° à 141,2°, 71° à 132,2° et 5,8° à 19,7° (valeurs p < < 0,0001). Le remplissage moyen du calcar était de 0,86 (0,32 – 1,17 +/- 0,22). Les remplissages canalaire moyens proximal et distal étaient respectivement de 0,62 (0,48 – 0,73 +/- 0,06) et 0,56 (0,36 – 0,71 +/- 0,09). Le taux de complications postopératoires était de 22,5 %.

Conclusion: Les tiges sans ciment améliorent les résultats fonctionnels à moyen terme avec un alignement satisfaisant et un remplissage canalaire <0,7 dans tous les cas. L'incidence du stress shielding est légèrement plus élevée sans impact sur les résultats cliniques.

Mots clés: Épaule, Arthroplastie, Tige, Fixation, Résultats

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Introduction

Reverse total shoulder arthroplasty (RSA) was first introduced by Grammont et al. in 1987 to treat rotator cuff arthropathy, revision of failed previous surgeries, malunions fractures, and pseudoparalysis (1). The most common complication is scapular notching followed by loosening (1,2). Humeral loosening rates in RSA are generally higher than in conventional total shoulder arthroplasty (2). To mitigate the risk of loosening, cementless stems were introduced with clinical and radiographic outcomes comparable to cemented stems highlighting several benefits of cementless fixation such as risk of cement-related complications, reduced operative time, simplified surgical technique, and easier revisions (3). Actually, convertible modular systems facilitate transition from total to reverse arthroplasty there by decreasing surgical time, avoiding removal of well-fixed humeral stems, and providing excellent functional outcomes (3,4). This study aimed to analyze functional results and complications rates of cementless stem in RSA.

Methods

We conducted a retrospective review of 40 consecutive patients who underwent cementless RSA performed from January 2016 to December 2020, with a minimum follow-up of 4 years. Used reverse shoulder system featuring a cementless cobalt chrome humeral component. Humeral stem is available in several diameters and two lengths with 135° neck-shaft angle lateralization of the humerus (Figure.1).

Figure 1. Cementless reverse shoulder arthroplasty with a 135° neck–shaft angle (NSA).

All surgeries were performed by the same surgeon. Indications included rotator cuff arthropathy, massive irreparable tears with pseudoparalysis, post-traumatic glenohumeral arthritis, and primary osteoarthritis with massive irreparable cuff tear. Exclusion criteria comprised poor preoperative deltoid function, cervical spine issues and no complete follow-up. All procedures involving human participants adhered to the ethical standards set by the institutional and/or national research committee, as well as the 1964 Helsinki Declaration and its later amendments. Since this study was retrospective, formal consent was not required.

Operative Technique

Surgery was performed in beach chair position using deltopectoral anterior approach with protection of cephalic vein. Upper part of pectoralis major tendon was released and medial border of deltoid muscle was retracted laterally while being partially released from its distal insertion through subperiosteal dissection. A longitudinal incision was made in tendinous portion of subscapularis muscle. Both capsule, and subscapularis tendon was tagged with nonabsorbable sutures for easier identification during closure. To expose humeral head, humerus was externally rotated and extended. A trocar-pointed reamer was used to bore a pilot hole through humeral head, aligned with humeral axis shaft, located just lateral to articular surface and slightly posterior to bicipital groove. The tapered humeral reamer was inserted up to engraved line above cutting teeth. A resection guide boom was attached to reamer shaft with 20° of retroversion. A saw blade was placed in the guide's cutting slot to cut humeral head and a calcar planer was employed to refine the resected surface (Figure.2: a). A 3.2-mm Steinmann pin was inserted into glenoid at desired tilted angle and position. The cannulated baseplate reamer was positioned over the pin, and reamed until appropriate level (Figure.2: b). Glenoid baseplate was seated, and suitable peripheral screws were inserted (Figure.2: c). Appropriate glenosphere was selected and assembled with baseplate (Figure.2: d). Glenosphere implant was placed into the impactor base using glenosphere forceps. The stem was inserted into humeral canal, finally, the correct humeral tray and bearing were assembled (Figure.2: e,f).

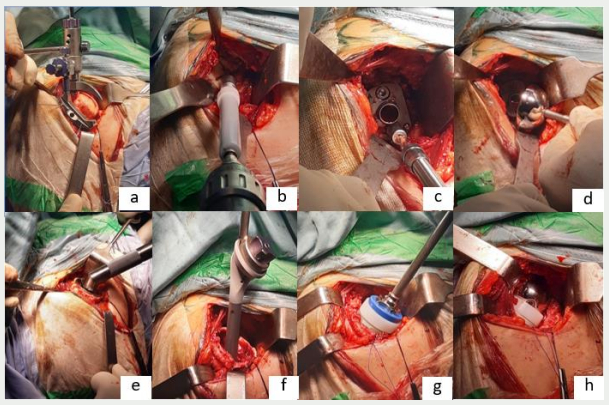

Figure 2. a) Exposure and proximal cut of humeral head with 20° of posterior retroversion, **b)** Exposure of glenoid preparing peg hole, **c)** Fixation of baseplate component with both superior and anterior 6 mm cancellous full threaded screws according to scapula orientation, **d)** Implantation of glenosphere on the baseplate, **e)** Preparing of humerus with the metaphyseal reamer, **f)** Implantation of cementless partial coated humeral stem respecting 20° of posterior retroversion, **g)** Assemblage of the definitive inset after final testing to humeral stem, **h)** Final aspect of the reverse shoulder arthroplasty after reduction of components.

Postoperative Rehabilitation

An abduction brace was applied postoperatively for 4 weeks. Pendulum exercises were started immediately whereas passive motion exercises began 2 weeks later using a continuous passive motion machine. After 4

weeks, the abduction brace was removed, and activities were allowed as tolerated. Complications were reviewed and established.

Clinical Evaluation

Preoperative and postoperative functional outcomes were assessed by two different orthopedic surgeons evaluating visual analog scale (VAS), University of California Los Angeles (UCLA) score, and Constant score. Range of motion (ROM) include active anterior elevation, abduction, external rotation and internal rotation, were also revealed.

Radiographic Evaluation

Radiographic evaluations were conducted at 1, 2, 3 and 4 years postoperatively assessing position of glenoid component, as well as signs of osteolysis or scapular notching (5). Signs of stress-shielding were identified by comparing images at last follow-up with those obtained immediately after surgery. Measured parameters included Neck shaft angle (NSA): between diaphyseal axis and the perpendicular of reversed tray (Figure.3: a) evaluating misalignment (6). Postoperative NSA were compared to 135°: NSA of 135 ± 5° were considered normal, NSA > 140° were considered in valgus and NSA < 130° in varus. Calcar filling ratio (CFR) calculated by dividing mediolateral width of the stem by inner bone cortex, both taken perpendicular to diaphyseal axis 1 cm below medial calcar-prosthesis junction (Figure.3: b) (6). Measurement of filling ratio in proximal and distal sides: Filling ratio in metaphysis (FRmet) is a line perpendicular to shaft axis, intersecting at distal–medial border of the humeral platform. Filling ratio in diaphysis (FRdia) is a line perpendicular to shaft axis, intersecting at distal third of the stem. The filling ratio is the quotient of humeral distances on stem distances proximally and distally (Figure.3; c, d). Filling ratios greater than 0.7 were classified as excessive (6).

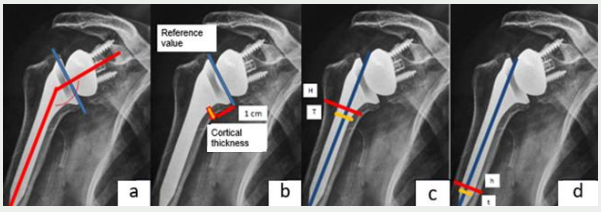

Figure 3. a) NSA: angle to assess alignment of humeral stem, **b)** CFR: Calcar filling ratio to assess proximal humeral osteolysis, **c)** Proximal filling ratio (Frmet), **d)** Distal filling ratio (FRdia).

Statical analysis

Data analysis was performed using IBM SPSS (IBM Co., Armonk, NY, USA), and paired t-tests were used to compare preoperative and postoperative clinical scores and range of motion.

Results

Demographic features

The study included 14 males and 26 females with sex-ratio of 0.53. Mean BMI was 28.2 Kg/m² (23.7-32.1). The mean age was 67.7 years (60 -82), with a mean follow-up duration of 39 months (48 -98). Preoperative indications were: 14 cases of massive cuff tear (35%), 10 cases of primary osteoarthritis (25%), 6 cases of post traumatic osteoarthritis (15%), 4 cases of avascular necrosis of humeral head (10%), 4 cases of inflammatory arthritis sequelae (10%) and 2 cases of recurrent instability (5%).

Functional and Clinical Outcomes

Active anterior elevation, abduction, external rotation and internal rotation showed significantly enhancement respectively 80° to 141.2°, 71° to 132.2° and 5.8° to 19.7° (p values < <0.0001) (Table.1).

Table 1. Comparative assessment preoperative versus postoperative ROM outcomes

	Preoperative (°)	Postoperative (°)	Enhancement (°)	P
AAE	80 (50 - 90 +/- 21.4)	141.2 (82 - 171 +/- 21.6)	+61.2	<0.0001
ABD	71 (40-90 +/- 22.3)	132.2 (50 – 150 +/- 24.2)	+ 61.2	<0.0001
ER	5.8 (-10- 20 +/- 11.2)	19.7 (10 - 30 +/- 11.7)	+13.9	<0.0001
IR	(Trochanter-T12) 3.2 p	(Buttock - T7) 6.6 p	+ 3.4 p	<0.0001

ROM: Range of motion, **AAE**: Anterior active elevation, **ABD**: Abduction, **ER**: External rotation, **IR**: Internal rotation, **p**: points

Mean visual analog scale (VAS) score improved from 5 points preoperatively to 2.2 points (p = 0.014). Mean University of California Los Angeles (UCLA) score increased from 17.2 to 25.7 (p = 0.002), and Constant score rose from 31.89 to 70.2 (p < 0.001), indicating statistically significant improvements (Table.2).

Table 2. Comparative assessment preoperative versus postoperative functional outcomes

	Preoperative	Postoperative	P
VAS	5	2.2	0.014
CONSTANT	31.89 points (15 - 45 +/- 7.1)	70.2 points (40 - 81 +/-10.7)	<0.0001
UCLA	17.2	25.7	<0.0001

VAS: visual analog scale, **UCLA**: University of California Los Angeles

Radiologic Outcomes

At last follow-up, radiographs did not find any mechanical complications of humeral stem. Neither prosthetic disintegration was reported, nor fracture or migration of the implant. At mean follow-up of 39 months, cementless stems showed perfect prosthetic stability. Calcar osteolysis was observed in 6 cases (15%) with a mean onset time of 18 months. The mean calcar filling

ratio was 0.86 (0.32 – 1.17 +/- 0.22). The mean proximal and distal filling ratios were 0.62 (0.48 – 0.73 +/- 0.06) and 0.56 (0.36 – 0.71 +/- 0.09) respectively. The mean NSA was 136.7° (132° - 144°+/- 3.7°). Twelve stems were valgus, with a measured angle greater than or equal to 140°. There was no loosening of the glenoid component or periprosthetic border around the baseplate. No mechanical complications were found. Scapular notching was reported in 4 cases (10%) all grade 1. No periprosthetic radiolucency's line > 2mm was observed for the humeral stem. Periprosthetic radiolucency's lines < 2mm were observed in 6 cases (15%). Stress Shielding was revealed in 4 cases (10%).

Complications

Concerning intraoperative complications, 14 complications (35%) were documented: 4 cases of cephalic vein disruption treated with ligation, 2 cases of excessive glenoid reaming, 4 cases of obsolete fixation of baseplate screws, 1 case of iatrogenic humerus cortex fissure during insertion of humeral stem, detaching a small cortical fragment (Figure.4: a). This fragment was reinserted by osteo-suture and 1 case of humeral shaft fracture during insertion of the intramedullary guide in patient with post trauma sequela modifying proximal humeral extremity treated with long stem with cerclage (Figure.4: b).

At last follow-up, 19 postoperative complications were reported (35%). No surgical revision was indicated for disintegration of the humeral stem. Scapular notching was reported in 4 cases (10%) all grade 1 (Figure.4:c). Proximal osteolysis was reported in 6 cases (15%). Stiffness was reported in 9 cases (22.5%).

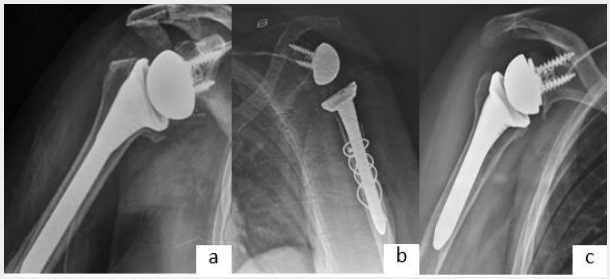

Figure 4. a) Fracture of calcar, **b)** Perioperative fracture of the humeral shaft during reaming, **c)** Notching grade 1.

Discussion

The introduction of RSA marks a significant advancement in shoulder surgery providing treatment for rotator cuff arthropathy (1,4,6). Various studies have reported complication rates for RSA varying widely, from 14% to 75% (2,7). Therefore, it is crucial to consider these rates when selecting patients. In our study, we aimed to evaluate clinical and functional outcomes describing types and rates of early complications associated to cementless stem RSA. Cementless stem is characterized by proximal fixation with standard stem length, a conical proximal shape with an ovoid cross-section, and an in-growth–type (trabecular metal) surface coating. The most described complication of cementless fixation is stress shielding (8). Several risk factors have been reports as high-risk factors such as: female, distal (diaphyseal) fixation, long stems, press-fit or on-growth–type stem coating and high canal filling ratio (9,10). All patients who had stress shielding were female, which suggests that osteoporosis may influence incidence of this complication (8,10). Several previous studies reported that stress shielding occurs more frequently in cementless fixation than in cemented (9,11). It is characterized as adaptation to stress distribution as it has been well evaluated in hip arthroplasty, suggesting that long stem and high CFR provide stress reduction in the proximal part of the bone leading to bone resorption even in shoulder arthroplasty (12). Stress shielding rates vary from 9% to 97% (11-13). Indeed, comparing the results of inlay versus onlay arthroplasties, it seems that onlay arthroplasties were associated with a significantly increased risk of stress shielding (odds ratio, 10.6; P ¼ .014) (14). Humeral stress shielding was observed in 4 cases but without impact on clinical outcomes apart from lateral metaphysis thinning, which was associated with reduced active anterior elevation and slightly lower Constant score. In our study, patients with stress shielding had high canal filling ratio both in the proximal and distal parts of the humerus but not statistically significant (0.057). Moreover, canal filling ratio > 0.7 or > 0.8 were not associated with the incidence of stress shielding which did not support the results of previous studies indicating that canal filling ratio > 0.8 for RSA increases the rate stress schielding (9,11,15). This suggests that ovoid shape of the proximal part of the stem provides adequate stress distribution around the stem. A previous study compared 2 different stem designs (noncurved vs. curved stem) and demonstrated that incidence of bone adaptation change was significantly higher in curved stems than in noncurved stems, although the canal filling ratio was higher in the noncurved stem (16). Likewise, the valgus-varus alignment indicated that the curved stem may affect bone stress (17). The used cementless stem, with its oval cross-sectional shape and noncurved design, may result in a low incidence of stress shielding. The absence of surface coating on the distal half of the stem seems to avoid the occurrence of diaphyseal bone condensation, a phenomenon classically associated with RSA (18). In fact, no significant clinical or radiographic differences between cemented and cementless RSA were identified with several advantages of cementless fixation, such as eliminating cement-related complications, reducing operative time, simplifying the surgical technique, and facilitating easier revisions (19). Bogle et al. highlighted that cementless trabecular metal porous-coated implants offer secure glenoid fixation with minimal signs of humeral stem loosening or subsidence during short-term follow-up (20). These benefits make cementless stem an appealing option for surgeons in the learning phase of the procedure. Some studies have suggested that short and mid-term functional outcomes following cementless RSA are promising (19-21). For instance, Sirveaux et al (5). reported an increase in Constant score from 22.6 to 65.6 points postoperatively,

with 96% of patients experiencing little to no pain and an increase in mean active anterior elevation from 73° to 138°. Conversely, Boileau et al (21). found that RSA for post-traumatic arthritis or revision arthroplasty had less improvement and higher complication rates compared to those with degenerative rotator cuff arthropathy. In our study, all clinical scores (VAS, UCLA, Constant) and range of motion measures showed improvement.

The most commonly reported complication is scapular notching, followed by issues such as glenoid and humeral loosening, periprosthetic fractures, acromial fractures, neurological injuries, and infections (22,23). Rates of scapular notching have been reported to vary from 0% to 97% (23,24). According to Mollon et al (24), patients with scapular notching experience poorer clinical outcomes, reduced strength, limited range of motion, and significantly higher complications rates. Roche et al (25). also indicated that scapular notching can contribute to initial instability of the glenoid baseplate. Given the implications of scapular notching, efforts to prevent it are critical, and shoulder surgeons must be meticulous during glenoid preparation and baseplate placement. Grammont's initial design involved an NSA of 155°, but this has subsequently been modified, to avoid scapular notching in particular (26). Several computer modeling studies have suggested that reducing the NSA from 155° to 145° or 135° significantly improves arc movement (26-28). Our patients had significantly increased ranges of motion postoperatively and very little high grade scapular notching. the presence of significant glenoid notching increases the risk of osteolysis in this part of the humerus in relation to inflammatory reactions triggered by the release of polyethylene or metal particles (29). However, the follow-times in our study are too short to confirm these findings. In our study, scapular notching was revealed in 4 cases without interfering on functional outcomes. In fact, larger studies with long-term follow-up are needed to thoroughly evaluate scapular notching. Previous research has identified optimal strategies for preventing scapular notching, such as inferior positioning of glenoid baseplate and using larger implants with shallower concave components (30,31). The reported incidence of infection after RSA ranges from 0% to 4%, while prevalence of neurological injury is approximately 1% to 4.3% (32). The axillary nerve is commonly affected, potentially suffering injury from direct trauma during surgery, stretching from retractors, or postoperative hematoma compression (33). In most cases of neurological injury, surgical intervention is not required (33). Gilot et al (34). reported on the incidence of radiographic aseptic loosening of humeral component in RSA, finding no loosening in the press-fit group compared to cemented implants, without a statistically significant difference in humeral stem loosening overall (35). Sershon et al (36). reported 14% complication rate, including three revisions within four years, with a total survival rate of 91% among 36 patients with a mean age of 54 years. Concerning survivorship, Sirveaux et al (5). documented prosthesis survivorship rates of 88% at five years, 71.9% at seven years, and 28.8% at eight years postoperatively. Schnetzke et al. (36) and Peduzzi et al (37) observed medial bone remodeling in respectively, 82.7% and 72.2% of cases, confirming that misalignment in the frontal plane and high filling ratios are risk factors for radiographic alterations. Our overall complication rate was 22.5% (19 out of 40 patients). There were no complications or reoperations requiring replacement of the humeral stem.

This study has several limitations. First, the sample size was relatively small. Second, the follow-up period averaged only 39 months, which may not capture full extent of potential complications, as previous studies have shown increased complications rates with longer follow-up. Third, the study exclusively utilized the Scultra® reverse shoulder system (Euros France) with cementless components, without comparison to other systems or cemented RSA. The single-center and single-operator nature of the study, which ensured homogeneity in terms of surgical technique, are its main strengths. The standardized radiographic protocol allowed a detailed analysis of factors potentially associated with stress shielding.

Conclusion

The mid-term follow-up for cementless RSA demonstrated satisfactory clinical and functional outcomes. Stress-shielding was slightly higher without impact on outcomes. Long-term follow up is required to assess survivorship and bone stock around the stem.

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