Survie et, résultats fonctionnels et radiologiques des prothèses totales d'épaule inversées vs hémiarthroplasties traumatiques avec un recul moyen de 50 mois

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Survie et, résultats fonctionnels et radiologiques des prothèses totales d'épaule inversées *vs* hémiarthroplasties traumatiques avec un recul moyen de 50 mois

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Liste des abréviations:

AP view : Anteroposterior view

ER1 : External rotation

HA : Hemiarthroplasty

ONATH : Ostéonécrose avasculaire de la tête humérale

ROM : Rang of motion

RSA : Reverse shoulder arthroplasty

SD : Ecart type

T.E.S.S : Total Evolutive Shoulder System

Remarques préalables:

L’ensemble de ce travail est destiné à être publié.

Aussi, une grande partie de cette thèse a été rédigée en anglais, conformément aux éxigences des éditeurs et afin de limiter au maximum tout biais de traduction.

Une introduction, un résumé IMRAD et une conclusion générale en français structurent ce travail.

Nous n’avons aucun conflit d’intérêt et aucune contribution financière n’a été perçue pour la réalisation de ce travail.

1. Introduction générale

1.1 Contexte

La prévalence des fractures de l'extrémité supérieure de l'humérus augmente dans notre société et constitue un problème majeur de santé publique. Elle représente actuellement la troisième fracture la plus fréquente chez les personnes de plus de 65 ans [1].

Les fractures non déplacées ou peu déplacées peuvent généralement être traitées orthopédiquement avec de bons résultats [2–4]. Une fracture déplacée peut nécessiter un traitement chirurgical [5]; Cependant, la gestion de ces traumatismes n'est actuellement pas très consensuelle. L'ostéosynthèse à foyer ouvert, par plaque verrouillée ou à foyer fermé, par clou huméral verrouillé permet une fixation stable[6]. Néanmoins, chez les patients âgés, en raison d'une ostéoporose et d'un risque élevé d'ostéonécrose céphalique ou de pseudarthrose, les fractures complexes de l'extrémité supérieure de l'humérus nécessite parfois une arthroplastie d'épaule type hémiarthroplastie(HA) [7] (Illustration 1). Cependant, réussir une hémiarthroplastie traumatique est un réel challenge chirurgical. En effet, la reconstruction anatomiques des tubérosités, la restauration de la longueur humérale et la rétroversion humérale sont parfois difficiles à obtenir.

Illustration 1. Radiographie d'épaule gauche, de face, en rotation neutre, chez un homme de 61 ans, à 24 mois d'une hémiarthroplastie post-traumatique. Tubérosités consolidées et en position anatomique.

Le suivi à long terme de ces prothèses a fait l'objet de nombreuses études qui ont mis en évidence certaines limites [8], notamment du fait que le résultat fonctionnel de l'HA dépend en grande majorité de la consolidation des tubérosités [9].

Par la suite, en raison de son succés dans le traitement de l'omarthrose excentrée, l'arthroplastie d'épaule inversée (RSA) (Illustration 2) s'est avérée être une solution viable dans l'arsenal thérapeutique des fractures humérales cephalo-tubérositaires type 3 ou 4 du sujet âgé [10,11]. Les résultats semblent dépendre d'avantage du muscle deltoïde que de la consolidation des tubérosités et de l'intégrité de la coiffe des rotateurs. De plus, le rétablissement des patients et leur reprise d'autonomie y est plus rapide, avec une rééducation moindre [12].

Illustration 2. Radiographie d'épaule droite, de face, en rotation neutre, chez une femme de 84 ans à 49 mois d'une prothèse gléno-humérale inversée post-traumatique.

Bonnevialle et al. a retrouvé de bons résultats à court terme de la RSA dans son indication traumatique [13] ; De plus, leur utilisation augmente récemment avec, la nouvelle génération de chirurgiens spécialisés dans l'épaule [14,15] et l'arrivée sur le marché des nouveaux implants traumatiques. Malgré tout, la HA reste le gold-standard car la survie de la RSA est controversée [16,17].

1.2 Objectif

Le but de cette étude rétrospective était, d'une part, de comparer les résultats 1) fonctionnels et 2) radiologiques de la RSA avec l'HA chez le patient âgé présentant une fracture récente de l'extrémité supérieure de l'humérus, et d'autre part de comparer 3) la survie à moyen terme de ces deux types d'arthroplasties.

1.3 Hypothèse

Notre hypothèse est qu'une fracture complexe de l'extrémité supérieure de l'humérus, déplacée, du sujet agé doit être prise en charge par une RSA.

2. Facteurs predictifs d'ostéonécrose avasculaire de la tête humérale lors d'une fracture complexe de l'extrémité supérieure de l'humérus

Hertel et al.[18] a décrit en 2004, 3 facteurs predisctifs d'ostéonécrose aseptique de la tête humérale (ONATH) dans les suites d'une fracture complexe de l'extrémité supérieure de l'humérus :

- Fracture type 3-Part et 4-Part selon Neer[2] (Illustration 3), avec un déplacement angulaire de la tête supérieur à 45°, un déplacement des tubérosités supérieur à 1 cm, un refend articulaire et/ou une luxation glénohumérale associée.
- Perte de la charnière médiale : ouverture > 2mm de la charnière interne de la tête, impactée en valgus.
- Extension métaphysaire postéro-médiale de la fracture (éperon), solidaire du fragment céphalique, absente ou inférieure à 8mm.

Avec une valeur predictive positive d'ONATH de 97% !
En effet, l'ensemble de ces facteurs compromettent la vascularisation de le tête humérale, assurée principalement par deux branches de l'artère axillaire : le pédicule antérolatéral (artère arquée), terminaison de l'artère humérale circonflexe antérieure, et le pédicule postéromédial, terminaison de l'artère circonflexe humérale postérieure.

D'autres facteurs secondaires aggravent le risque d'ONATH :

- Age supérieur à 60 ans
- Statut ostéoporotique, qui augmente avec l'âge et le sexe féminin.
- Enfin Tingart et al.[19] suggère que la mesure de l'épaisseur des corticales humérales pouvait être un indicateur de la densité osseuse de l'humérus proximal. Ainsi, une épaisseur corticale moyenne inférieure à 4 mm au niveau de la jonction diaphyso-métaphysaire serait prédictive d'une mauvaise qualité osseuse au niveau de l'épiphyse.

Ainsi, un remplacement prothétique (HA ou RSA) peut être indiqué chez le sujet âgé en cas de fracture complexe de l'extrémité proximale de l'humérus présentant des facteurs predictifs d'ONATH.

Illustration 3. Radiographie d'épaule gauche, de face. Fracture de l'extrémité supérieure de l'humérus type 4-Part selon Neer chez une femme de 75 ans.

3. Total Evolutive Shoulder System (T.E.S.S®)

Les prothèses T.E.S.S® Trauma Monobloc ont été conçues pour la prise en charge des fractures complexes de l'extrémité supérieure de l'humérus.

3.1 La tige

La tige (Figure 3), en chrome-cobalt, est unie à la corolle (HA) ou à la corolle inversée (RSA) en une seule pièce. Elle doit toujours être cimentée. La corolle et la corolle inversée sont constituées en chrome-cobalt avec un double révètement de titane poreux et d'hydroxyapatite. Elles sont conçues pour optimiser la consolidation des tubérosités:

- d'une part, grâce aux espaces permettant d'impacter une greffe cortico-spongieuse
- d'autre part, grâce aux multiples trous de suture permettant la fixation des tubérosités entre elle, à la prothèse et à la greffe osseuse.

Illustration 4. Tiges de la T.E.S.S® Trauma Monobloc: HA (*à gauche*) et RSA (*à droite*).

3.2 L'embase glénoïdienne

L'embase glénoïdienne (RSA), en alliage de titane, est conçue pour limiter le risque de descellement (Figure 4). Sa surface postérieure, constitué d'un double revètement de titane poreux et d'hydroxyapatite, intègre:

- une partie plane périphérique
- une partie centrale convexe avec une quille pouvant accueillir : soit une vis centrale de compression, soit une extension de quille, dans les cas d'une qualité osseuse insuffisante ou en cas de révision
- une fixation primaire, par 2 vis inférieure et supérieure orientables et, par 2 picots antéropostérieurs pouvant être remplacés en per-opératoire par des vis. Les vis, en titane, sont autotaraudeuses, autoperforantes, retro-coupantes et autobloquantes. Elles sont orientables et verrouillables *en supérieur et inférieur*, unidirectionnelles et verrouillables *en antéro-postérieur*

L'embase glénoïdienne est impactée sans ciment.

Illustration 5. Embase glénoïdienne T.E.S.S® (RSA).

3.3 La glénosphère

La glènosphère, en chrome cobalt, est impactée sur l'embase glénoïdienne à l'aide d'un cône morse central (Figure 5). Elle est centrée et comporte une latéralisation du centre de rotation de 3mm permettant ainsi d'optimiser la rotation externe et la force en abduction comme l'a décrit Müller et al. [20].

Illustration 6. Glenosphère T.E.S.S® (RSA).

3.4 La tête anatomique

La tête anatomique, en chrome cobalt, est centrée ou excentrée, impactée sur la corolle via un cône morse (Figure 6).

Illustration 7. Tête anatomique T.E.S.S® (HA).

3.5 L'insert

L'insert pour la corolle inversée est en polyethylene ArCom (Figure 7)

Illustration 8. Insert pour la corolle inversée T.E.S.S® (RSA).

4. Reverse shoulder arthroplasty is superior to hemiarthroplasty to manage proximal humeral fractures in elderly patients: a mid-term survival retrospective study

4.1 Abstract

Introduction: The aim of the study was, firstly, to compare the 1) functional and 2) radiological outcomes of RSA with HA in elderly patients with acute proximal humeral fractures, secondly to compare the 3) mid-term survival of these two types of arthroplasty.

Methods: All patients treated by RSA or HA for acute proximal humeral fracture, in primary hospital center were retrospectively identified. The primary endpoint was absolute and weighted Constant-Murley score. We also performed a statistical survival analysis of Kaplan-Meier.

Results: Forty nine patients were included in the clinical and radiological analysis and 141 patients were included in the survival analysis. At the final follow-up, the absolute Constant Score was higher in the RSA group, but there was no significant difference between HA and RSA groups, respectively 57.4 ± 21.8 *vs* 65 ± 17.1 (p = 0.184). However, the weighted Constant score was clinically and statistically significantly better in the RSA group (HA : 81.16 ± 28.9 *vs* RSA : 108.04 ± 27.6 ; p = 0.001). The estimated mean survival time was 50 ± 6 months in the RSA group and 64 ± 8 months in the HA group. The analysis of the survival curve of Kaplan-Meier did not show any significant difference between the HA and RSA groups (p = 0.11)

Conclusion: By using an optimised surgical technique, with implants designed for trauma, RSA can be the first option in the management of complex proximal humeral fractures in patients older than 60.

Level of evidence: IV, retrospective study

Keyword: hemiarthroplasty; reverse shoulder arthroplasty; survival rate; functional outcome; humeral fracture.

4.2 Introduction

4.2.1 Background

The prevalence of proximal humeral fractures are increasing and constitute a major public health problem. It currently is the third most common fracture in people over 65 [1].
Undisplaced or minimally displaced fractures can usually be treated non-surgically with good outcomes [2–4]. Displaced fractures may require surgical treatment [5]; however the management of this trauma is currently not very consensual. Osteosynthesis by humeral locking plate or nail can permit stable fixation [6]. Nevertheless, in elderly patients due to osteoporosis and high risk of osteonecrosis or nonunion, complex proximal humeral fractures have been historically managed with shoulder hemiarthroplasty (HA).[7] Yet, it is a surgical challenge to achieve a good HA following a fracture. Indeed, anatomic tuberosities reconstruction, humeral length and retroversion are often difficult to perform. Long follow-up studies hightlight some limitations with this procedure [8], especially because functional outcomes of HA depend on the healing of tuberosities [9]. Thereafter, due to the success of reverse shoulder arthroplasty (RSA) in the treatment of cuff tear arthropathy, it was proved to be a viable solution for elderly patients with 3- and 4-part fractures [10,11]. Functional outcomes seem to depend on the deltoïd rather than on tuberosities healing and the rotator cuff's integrity. Furthermore, the recovery of patients is faster and they need less rehabilitation [12].
Although, Bonnevialle et al. showed RSA after fracture offers good results in short-term [13] and though their number is recently increasing with newly trained orthopedic surgeons [14,15] and with implants designed for trauma, HA remains the gold standard because survival after RSA is controversial [16,17].

4.2.2 Objective

The aim of this retrospective study was, firstly, to compare the 1) functional and 2) radiological outcomes of RSA with HA in elderly patients with acute proximal humeral fractures, secondly to compare the 3) mid-term survival of these two types of arthroplasty. Our hypothesis is that complex proximal humeral fracture in elderly patients should be managed with RSA.

4.3 Materials and methods

4.3.1 Patient Inclusion

From June 2007 to June 2017, all patients treated by RSA or HA for acute proximal humeral fracture, in primary hospital center were retrospectively identified by searching through our database for proximal humeral acute trauma.

Inclusion criteria were based on the Neer[2] classification (a four-part fracture, or a three-part fracture with severe comminution of the greater tuberosity, or a fracture-dislocation or a fracture that involved an articular split of the humeral head), in elderly patients over 60 years old, and who were all treated with a trauma shoulder arthroplasty. Exclusion criteria were a less than 12 months follow-up, a residence further than 150 km from the hospital, dementia or mental inability.

Indication to use RSA rather than HA was based on the patient's prior history of rotator cuff disease, severe tuberosity comminution preventing reconstruction, radiographic evidence of gleno-humeral arthropathy or rotator cuff tear shown on preoperative CT-scan.

Patients were asked to come to our shoulder consultation.Those who could not come at the hospital were seen at home. Patients who did not answer to the meeting notice, after being convened once by postal mail and twice by phone, were considered lost of follow-up.

All patients signed an informed consent form and gave their approval for the use of clinical and radiographic data for scientific purposes.

4.3.2 Surgical Technique

All arthroplasties were performed by a single shoulder surgeon, using cemented implants designed for fractures : Total Evolutive Shoulder System (T.E.S.S, BIOMET, Warsaw, US). All patients were operated under general anesthesia associated with an interscalene block, in the beach chair position, by a deltopectoral approach. Careful preservation between tuberosities and humeral shaft, and tenotomy-tenodesis of the long head of the biceps were first performed. In both groups, a suction drain was placed post-operatively for 48 hours.

HA group : the Anatomic T.E.S.S Trauma Monobloc was implanted in every shoulder. The height of the implant was based on humeral medial calcar and the implant was placed at 20° of retroversion compared to the forearm with the elbow bent at 90° as described by Kirschnan

et al. [21]. The choice of the size of the prosthetic head was always rounded to the smallest if the measurement of the native head was between two sizes. Centered head implants were always used; a cortico-spongy bone graft from the native head was impacted in hydroxyapatite and porous titanium corolla spaces. Tuberosities were sutured in anatomical position as discribed by Boileau et al.[9] with: a horizontal nonabsorbable suture using Max Braid® (through rotator cuff and corolla holes, to fasten tuberosities to each other, to the bone graft and to the corolla) and a vertical nonabsorbable suture using Mersuture® (to fix tuberosities to humeral shaft). The rotator cuff was closed with nonabsorbable suture. After surgery, the shoulder was fixed into internal rotation in an arm sling for 45 days and all patients were sent to a rehabilitation center. The postoperative rehabilitation followed Neer's program as described by Boileau et al. [22], with immediate passive rehabilitation and pendulum exercises. Active-assisted rehabilitation was started at 21st and active rehabilitation was started around the 45th day, after tuberosites consolidation.

RSA group : the Reverse T.E.S.S Trauma Monobloc was implanted in all shoulders. The same optimise surgical technique was used. The suprasupinatus tendon was totally resected. The glenoid preparation included : the resection of labrum, the removal of glenoid osteophytes, the use of a cannulated glenoid reamer, centered beforehand by a Kirschner wire. The glenoid baseplate's size was always rounded to the smallest if the measurement was between two sizes. It was placed slightly next to the inferior glenoid border and with 10° of inferior tilt, and the inferior screw was always fixed first to decrease the risk of scapular notching. As the same, the height of the implant was based on humeral medial calcar and the implant was placed at 0° of retroversion. The polyethylene implant's size was chosen to optimise stability, laxity and deltoid tension. Then, tuberosities were fixed into anatomical position, as described previously, using if necessary cortico-spongy bone graft inserted around the hydroxyapatite reverse corolla. After surgery, shoulder was fixed into internal rotation in a sling for 45 days and all patients were sent to a rehabilitation center. The rehabiliation was shorter than the HA group, with active reeducation beginning earlier, around the 21st day.

4.3.3 Clinical outcome Measures

Clinical examination was performed by an independent assessor, not involved with the surgical treatment of these patients. The primary endpoint was absolute Constant-Murley score and weighted Constant-Murley score, adjusted for age and gender (annexe n°1) [23].

Strength was measured with the arm at 90 ° anterolateral elevation while maintaining resisted elevation against a conventional spring balance dynamometer. Range of motion (ROM) was mesured using a digital goniometer.

4.3.4 Radiographical Analysis

Radiological assessment was performed by an independent radiologist. Standard X-rays included a true anteroposterior (AP) view in neutral rotation and a Lamy's profil view. Tuberosities' healing was graded as healed or non-union (evidence of a fracture line on the X-ray, evidence of tuberosity resorption or superior/posterior migration). Humeral and glenoid component loosening was measured using the grading system described by Sperling et al.[24]. Heterotopic ossifications were assessed using Sneppen et al. classification [25]. In cases in which tuberosities non union or implant loosening were suspected, a CT scan was performed. For the RSA group, inferior scapular notching was classified by Nerot's classification (annexe n°2) [26].

4.3.5 Survival Analysis

We performed a statistical survival analysis of Kaplan-Meier. The starting-point was the date of the initial surgical procedure. Specific events were death or surgical revision. Data were censored if patients reached the end of the study, developed dement or were lost of follow-up.

4.3.6 Statistical Analysis

Based on the postoperative Constant score published, we calculated the sample size needed to have 2 comparable groups with a Constant Score difference of 10.4 [27], a power of 80% and an α risk of 5%; 25 patients were required in each groupe. Statistical analysis was performed by an independent statistician. For the clinical and radiological analysis, we performed per-protocol analysis, so patients who underwent surgical revision were excluded. Qualitative variables were compared using the Khi-deux and Fisher test to detect differences between preoperative and postoperative values. The student's t-test was used for quantitative variables. Regarding the survival analysis, we did an intention to treat analysis. The log-rank test was used to compare survival curves. The hazard ratio with its 95% confidence interval (CI) was calculated to compare the survival rate between the two groups. Statistical analysis was

performed for all data using a SPSS software (SPSS, Chicago, Illinois). A *p* value of 0.05 was considered as statistically significant.

4.4 Results

4.4.1 Epidemiological data

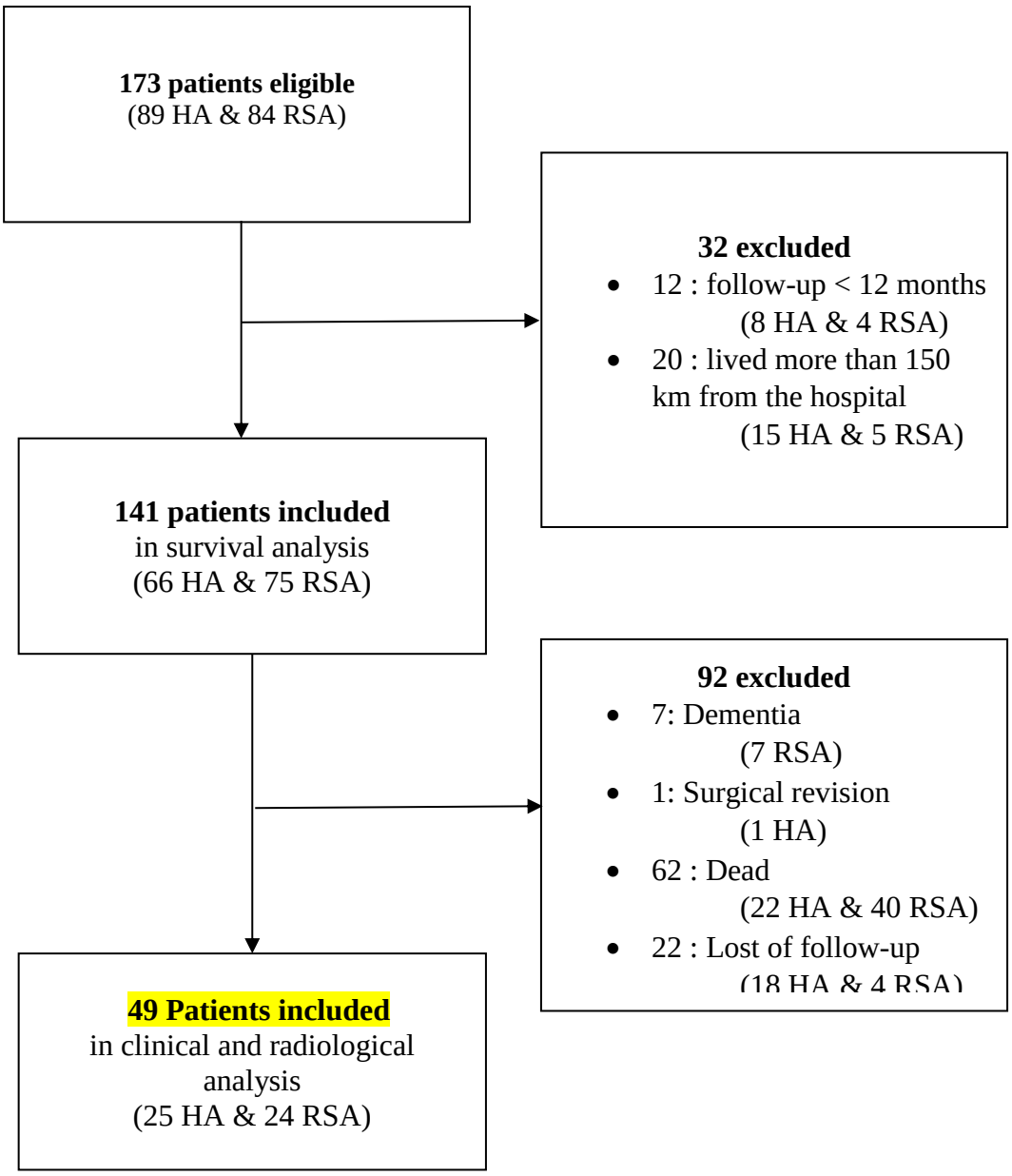
Patient distribution is figured on the flowchart (Figure 1).

In total, 173 patients (89 HA et 84 RSA) were treated with a trauma shoulder arthroplasty during the studied period.
First, 32 patients were excluded from the survival analysis: 12 because their follow-up lasted less than 12 months and 20 because they lived more than 150 km away from the hospital. In the end, 141 patients were included in the survival analysis.
Then, 92 patients were furthermore excluded from clinical and radiological analysis: 62 died, 7 developped dementia, 1 needed surgical revision and 22 were lost of follow-up.

Thus, 49 patients were evaluated. The RSA group included 24 patients with a mean age of 88.25 years old and a mean follow-up of 54.25 ± 24.8 months (range, 13-111) ; The HA group included 25 patients with a mean age of 71.68 years old and a mean follow-up of 46.84 ± 25.9 months (13-116).

Patients were significantly older in the RSA group than in the HA group (p=0.0001). There were no significant difference between the two groups for the Neer classification, sex or surgical shoulder dominant side (Table 1).

Figure 1. Flowchart of patient distribution.



HA: hemiarthroplasty, RSA: reverse shoulder arthroplasty

Table 1. Characteristics of the compared groups.

Criteria	HA group *n=25*	RSA group *n=24*	p value
Follow-up (months)	46.84 ± 25.9 (13-116)	54.25 ± 24.8 (13-111)	0.13
Age (years)	71.68 ± 10.59 (61-91)	88.25 ± 4.95 (76-96)	0.0001*
Gender (Male/Female)	8/17 (32%/68%)	3/21 (12%/88%)	0.2
Neer classification (3-part/4-part)	2/23 (8%/92%)	3/21 (12%/88%)	0.5
Arthroplasty on dominant side (yes /no)	13/12 (52%/48%)	14/10 (58%/42%)	0.2

HA: hemiarthroplasty, RSA: reverse shoulder arthroplasty, Quantitative data are expressed as mean ± standard deviation (range), qualitative data are expressed as effective (percentage). * Significant (<0.05)

4.4.2 Question 1 : Clinical results

Constant score : In the final follow-up, the absolute Constant Score was higher in the RSA group, but there was no significant difference between the HA and RSA groups, respectively 57.4 ± 21.8 *versus* 65 ± 17.1 (p = 0.184). However, the weighted Constant score was clinically and statistically significantly better in the RSA group (HA : 81.16 ± 28.9 *vs* RSA : 108.04 ± 27.6 ; p = 0.001). Detailed comparison of the four dimensions of the Constant score is shown in table 2. The pain dimension (HA : 10.8 ± 3.3 *vs* RSA : 13.6 ± 2.6 ; p = 0.001) and the activity dimension (HA : 13 ± 4.4 *vs* RSA : 16.1 ± 3.6 ; p = 0.010) were significantly better in the RSA group.

Range of motion : There was no significant difference between the 2 groups for anterior elevation, abduction, external rotation (ER1) or internal rotation.

Table 2. Objective clinical result at the final follow-up.

	HA group n=25	RSA group n=24	P value
Constant Score			
Pain (/15 points)	10.8 ± 3.3	13.6 ± 2.6	0.001*
Activity (/20 points)	13 ± 4.4	16.1 ± 3.6	0.010*
Mobility (/40 points)	23.2 ± 8.7	24.7 ± 7.6	0.534
Strengh (/25 points)	10.6 ± 9.1	10.7 ± 6.2	0.947
Absolute (/100 points)	57.4 ± 21.8	65 ± 17.1	0.184
Weighted (%)	81.2 ± 28.9	108 ± 27.6	0.001*
Range Of Motion			
Active anterior elevation (°)	111 ± 35.7	110 ± 27.5	0.913
Abduction (°)	102.6 ± 32.3	103.7 ± 24.2	0.889
Active external rotation 1 (°)	43.8 ± 25.2	49.4 ± 25.2	0.443
Active internal rotation (°)	51.2 ± 23.9	58.3 ± 22	0.283

* significant result (<0.05)

4.4.3 Question 2 : Radiographical outcomes

Among all patients, 24 patients in the HA group and 14 patients in the RSA group had a X-ray acquisition at the final follow-up.

There were 7 (29%) cases of non-union tuberosities in the HA group, and 3 (21%) cases in the RSA group. All were confirmed by CT scans.

Adjusted to tuberosities status, the Constant score was significantly higher when tuberosities were healed in the HA group (healed : 66.5 vs non-union : 39.64 ; p = 0.0035), when it had no significant influence in the RSA group (healed : 67 *vs* non-union : 46 ; p = 0.07) (Table 3).

Table 3. Influence of tuberosities healing on the Constant score.

Absolute Constant score (/100 points)	Tuberosity healed	Tuberostity non-union	p
HA group (n=24)	66.5 (n=17)	39.64 (n=7)	0.0035*
RSA group (n=14)	67 (n=11)	46 (n=3)	0.07

n: number of patients in each group. * significant result (<0.05)

There were 3 (21%) cases of heterotopic ossification in the RSA group, all were graded 1 by the Sneppen classification. No heterotopic ossification were noted in the HA group.

There were no cases of component loosening in the 2 groups.

In the RSA group, there were 4 (28%) cases of low grade of inferior scapular notching (3 grade 1 and 1 grade 2 on Nerot's classification)

4.4.4 Question 3 : Survivorship

The survival analysis is represented by Figure 2 and Table 4. In the final follow-up, the estimated mean survival time was 50 ± 6 months in RSA group and 64 ± 8 months in HA group. The analysis of the actuarial survival curve of Kaplan-Meier didn't show a significant difference between the HA and RSA groups (p = 0.11). Globally, there was about a 20% mortality rate at 6 months after a complex proximal humeral fracture, whatever the arthroplasty (HA or RSA), and despite the fact that patients were significantly younger in the HA group. The hazard ratio was calculated at 0.6691 (95%IC, 0.4096 to 1.0930) favoring HA. However this hazard ratio was not significant as the confidence interval did include the value 1 (corresponding to equal hazards).

Figure 2. The statistical survival curve of Kaplan-Meier represents the probability (Y-axis) of surviving a given length of time (X-axis).

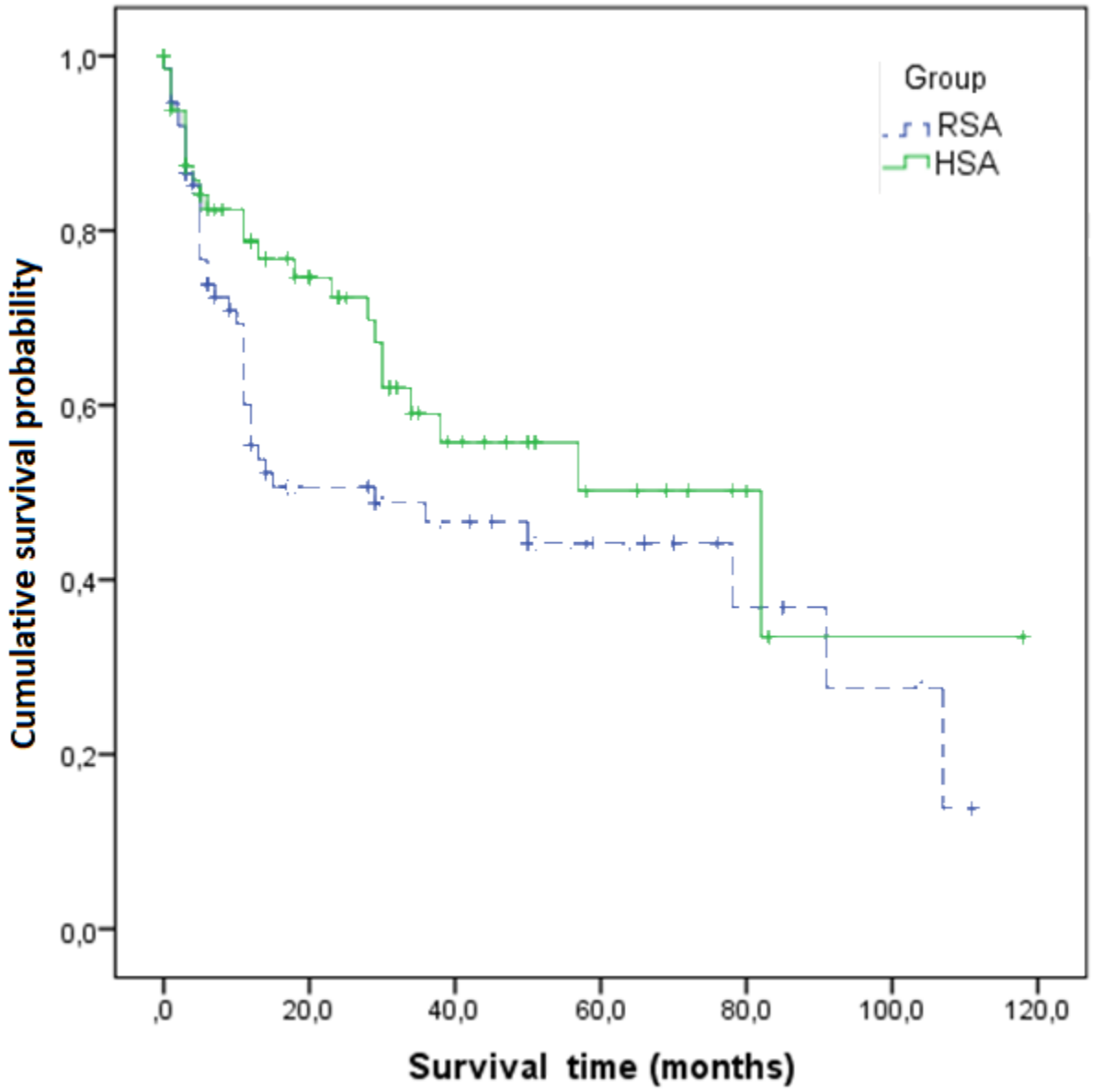


Table 4. Comparison of survival curves

	RSA	HA	
Sample size (number)	75	66	
Event (number, proportion)	40 (53%)	24 (36%)	
Censored (number, proportion)	35 (47%)	42 (64%)	
Estimated mean survival time (months, mean ± SD)	50 ± 6	64 ± 8	*p = 0,11*

4.5 Discussion

4.5.1 Main results

This study compares the functional and radiological outcomes of RSA *vs* HA in elderly patients with acute complex proximal humeral fractures. After 50 months of follow-up, weighted Constant score, pain and activity dimensions of the absolute Constant score were significantly better in the RSA group compared to the HA group. Moreover, there were less radiological complications in this former group. The study also compares the mid-term survival rate of these two kinds of arthroplasty, which was not significantly different.

4.5.2 Limitations

Because of its retrospective and monocentric design, this study has several limitations. Due to the acute nature of the shoulder fractures, the preoperative Constant score was unknown. To decrease this bias, we chose to normalize the post-operative data by using the weighted Constant score, ajusted to age and gender.

Furthermore, there was small sample size in each group. But before the study, we performed a sample size calculation to have enough statistical power. Moreover, the attrition bias is significant as there were consequent number of lost of follow-up. This is due to the age of the patients and the low survival rate of the victims of this kind of lesion. We tried to limit it by doing an intention to treat analysis for survival and a per protocol analysis for clinical and radiological outcome analysis.

Finally, to our knowledge, this comparative cohort of elderly patients is one of the largest studies in the litterature with a sufficient follow-up to draw a conclusion about the survival rate.

4.5.3 Question 1 : Clinical results

Although previous studies, comparing the outcome of these 2 procedures, remain limited by short follow-up or small numbers, it seems they indicate that the RSA offers better outcomes than the HA. Bonnevialle et al. on his retrospective, multicentric study, comparing 57 HAs

and 41 RSAs at a mean follow-up of 39 months, found, like our study, no difference in the Constant Score but showed significantly higher weighted Constant score, adjusted to age and gender [13]. Three other retrospective studies [28–30] with mean follow-ups between 12 months and 5 years attested that the RSA significantly outperform the HA using differents validated scores. These results was confirmed by some meta-analysis[31–33]; except one which found no difference in the ASES score (291 HAs and 110 RSAs) and a significantly higher Constant score for the HA group (420 HAs and 157 RSAs) at an average follow-up of 40 months [34]. Our study also shows better outcomes for the RSA at 54 months of follow-up. This results is all the more significant and surprising because the HA group was younger and in better health. Indeed, patients who benefited from a RSA were necessarily older, in poorer health and with poorer bone quality which predicted a worst result. Prospectively, Sebastia-Forcada et al. [35] compared 31 HAs and 31 RSAs with an average follow-up of 29.4 months, and Cuff et al. [36] compared 23 HAs and 24 RSAs with an average follow-up of 30 months : they found not only significant better functional results in favor of RSA, but they also found significantly higher ROM in the RSA group for forward elevation and abduction. This difference in abduction and forward elevation is also reported in others publications [13,28,30,31,34]. Results are more controversial concerning the active external rotation. As in our study, most of the authors did not report significant difference in ER1[13,31,36–38]. Ferrel et al. [34], and Gallinet et al. [28], attested that ER1 was significantly lower in the RSA group than in the HA group. However they used a surgical technique which consisted in removing rotator cuff and tuberosities for all cases in the RSA group. Sebastia-Forcada et al.[35] was the only one who showed significantly higher ER1 for the RSA group, probably because: tuberosities were all sutured into anatomical position[26,39], they used implants designed for trauma allowing bone graft between implant and tuberosities, and all patients from the RSA group were sent to a rehabilitation center, allowing quick recovery of ER1 under the control of physiotherapists. Those factors have not been verify in our study, but we think that they are of prime importance. It confirms that ER1, considered as one of the weaknesses of the RSA, is actually similar to the HA.

4.5.4 Question 2 : Radiographic results

As described by Boileau et al.[9], functional results of HA are more variable than RSA's and highly dependant on tuberosities status. Indeed, our results show a bimodal distribution of functional results in the HA group : tuberosities healing improves significantly the Constant score in the HA group, whereas there is non significant difference in the RSA group, whether

the tuberosities are healed or not. Furthermore, in our study, tuberosities healing seems better in the RSA group than in the HA group (80% *vs* 70% respectively). Wang et al.[38] showed that it can be explain by the biomechanics of RSA : forward elevation and abduction depend more on the deltoïd muscle rather than on the rotator cuff, and so it minimalizes the risk of tuberosities' non-union. Moreover, Robinson et al. [40] described that functional results of HA are deteriorated if surgery occurs after 70 years old, because of higher risk of degenerative rotator cuff tear and poor bone quality, increasing the risk of tuberosities' non-union. So, as it had been proven by several authors, RSA seems to be a reproductible procedure [10,13,26,28], and less dependant on the tuberosities' healing. Moreover, as suggested Nyffeler et al. [41] to avoid scapular notching, we used implants designed for trauma allowing the surgeon to place the glenoid base plate flush with inferior glenoid border, with 10° of inferior tilt, and including lateralisation of 3mm of rotation center to optimise external rotation and abduction strength [20]. We did not find any component loosening, but nevertheless we still had almost 30% of low grade scapular notching at final follow-up. It would be necessary to perform other studies analyzing the impact of low grade scapular notching on the long-term functional outcome.

4.5.5 Question 3 : Survivorship

Data concerning mid-terme survivorship after trauma shoulder arthroplasties is scarse in current litterature. Sebastia-Forcada et al. was the only one to compare survival rates between 31 HAs and 31 RSAs, with a short follow-up of 29 months on his recent study.[35] They demonstrated a longer survival rate for RSA compared to HA, while taking into account revision only or revision and clinical failure as events. This result is similar to ours. We considered revision or death as events because patients who present complex proximal humeral fracture are frail and with a lot of comorbidities, that leads them to be susceptible to a short term survival [42,43]. By doing so, we are closer to the real survival rate of elderly patients after arthroplasty than if we only considered revision. Our low revision rate in the HA group, even if the functional outcome was significantly lower than in the RSA group, can be explained by the fact that patients and physicians are ready to accept the poor outcome instead of choosing revision. Moreover, an often advanced argument to implant HA rather than RSA is that it is easier to revise a HA than a RSA. Nevertheless, Levy et al. [44] found that in the case of a revision of failed HA by RSA, despite an improvement on pain and function, the complication rate was up to 28%. Furthermore, Sebastia-Forcada et al. [35] found an unsuccessful outcome after revision of failed HA by RSA. In total, in our study, as

survival of shoulder arthroplasty after a fracture using a trauma design did not show a significant difference between the HA and RSA groups, while the RSA group is significantly older, it seems to imply the superiority of RSA in the management of complex proximal humeral fracture in elderly patients. This can compensate the fact that the RSA's cost is significantly higher than the HA's as shown Solomon et al.[45]

4.6 Conclusion

By using an optimised surgical technique, with implants designed for trauma, mid-term functional and radiological outcome of RSA is significantly better than HA for complex proximal humeral fractures in elderly patients.

This superority is maintained over time as the mid-terme survival of those two type of arthroplasty does not appear to be significantly different.

These results suggest that RSA can be the first option in the management of complex proximal humeral fractures in patients older than 60.

A long-term survival prospective study seems adequate to confirm that RSA is the best procedure, and should be the first intention method used to treat this lesion.

5. Conclusion générale

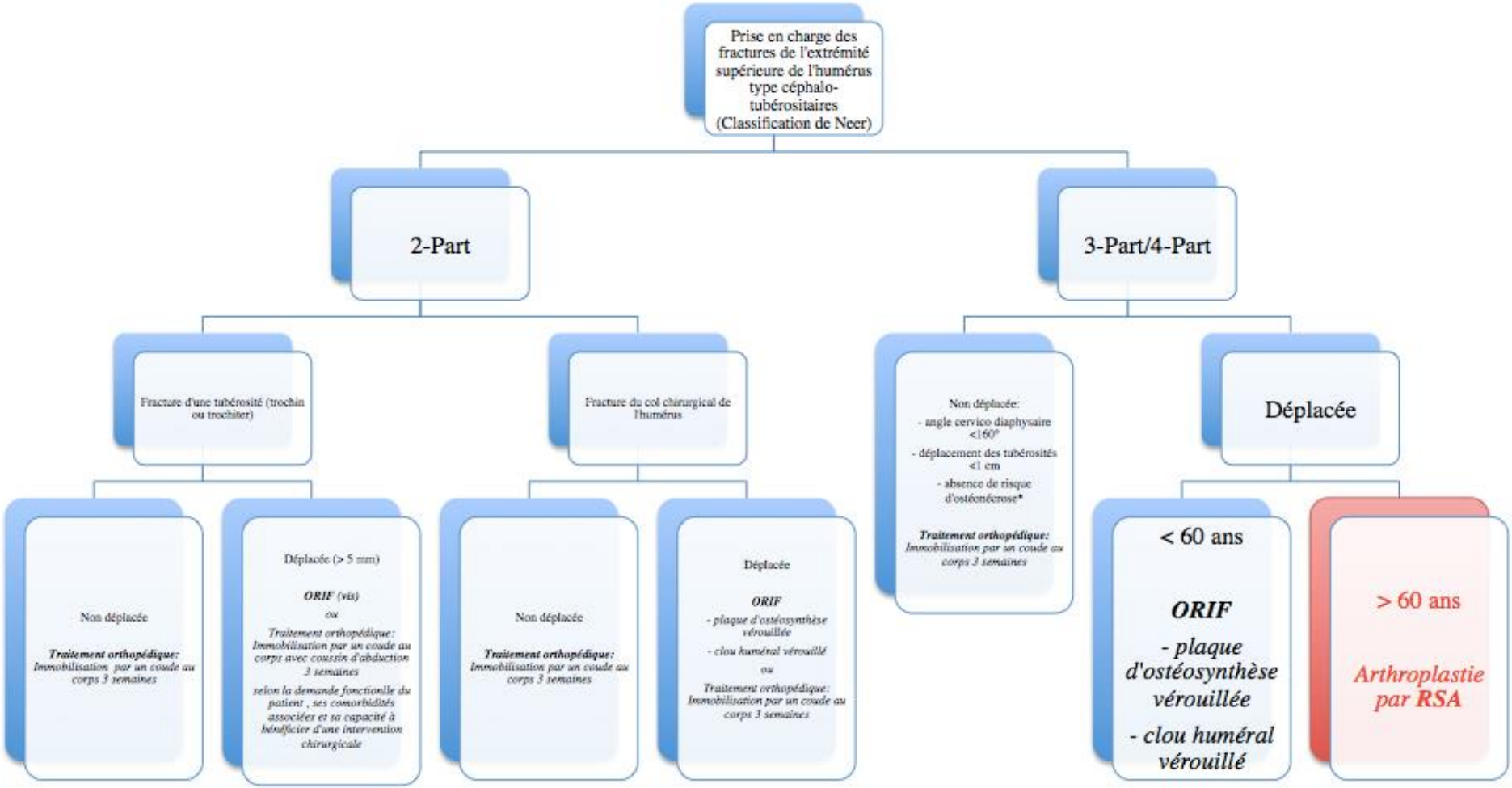
En utilisant une technique chirurgicale optimisée et des implants conçus pour les fractures, les résultats fonctionnels et radiologiques à moyen terme de la RSA sont significativement meilleurs que ceux de l'HA dans le traitement des fractures complexes de l'extrémité supérieure de l'humérus du sujet âgé.

La survie à moyen terme de ces deux types d'arthroplastie n'étant pas significativement différente, la supériorité de la RSA est donc maintenue dans le temps.

Ces résultats suggèrent que la RSA peut être l'option prioritaire dans la prise en charge des fractures complexes de l'extrémité supérieure de l'humérus chez les patients âgés de plus de 60 ans.

Une étude comparative, prospective et multicentrique sur la survie à plus long terme et avec d'avantage de patients apparaît néanmois nécessaire, afin de confirmer que la RSA est la meilleure solution de première intention dans le traitement de ces lésions.

6. Algorithme de prise en charge des fractures de l'extrémité supérieure de l'humérus



- Facteurs prédictifs d'ostéonécrose selon Hertel [18]:
  - Fracture type 3-Part et 4-Part selon Neer[2], avec un déplacement angulaire de la tête supérieur à 45°, un déplacement des tubérosités supérieur à 1 cm, un refend articulaire et/ou une luxation glénohumérale associée.
  - Perte de la charnière médiale
  - Extension métaphysaire postéro-médiale de la fracture (éperon), solidaire du fragment céphalique, absente ou inférieure à 8mm.

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Survie et, résultats fonctionnels et radiologiques des prothèses totales d'épaule inversées *vs* hémiarthroplasties traumatiques avec un recul moyen de 50 mois.

Résumé

Introduction : Le but de cette étude rétrospective était, d'une part, de comparer les résultats fonctionnels et radiologiques des RSA *vs* HA chez les patients âgés présentant une fracture récente de l'extrémité proximale de l'humérus, et d'autre part de comparer la survie à moyen terme de ces deux types d'arthroplasties.

Méthode : Tous les patients traités par RSA ou HA pour fracture récente de l'extrémité proximale de l'humérus dans notre centre hospitalier ont été inclus rétrospectivement. Le critère de jugement principal était le score absolu et pondéré de Constant-Murley. Nous avons également effectué une analyse statistique de la survie selon Kaplan-Meier.

Résultats : Quarante-neuf patients ont été inclus dans l'analyse clinique et radiologique et 141 patients ont été inclus dans l'analyse de survie. Au dernier recul, le score absolu de Constant était plus élevé dans le groupe RSA, mais il n'y avait pas de différence significative entre les groupes HA et RSA, respectivement 57,4 ± 21,8 vs 65 ± 17,1 (p = 0,184). Cependant, le score de Constant pondéré était cliniquement et statistiquement meilleur dans le groupe RSA (HA: 81,16 ± 28,9 vs RSA: 108,04 ± 27,6; p = 0,001). La survie moyenne était de 50 ± 6 mois dans le groupe RSA et de 64 ± 8 mois dans le groupe HA. L'analyse de la courbe de survie de Kaplan-Meier n'a montré aucune différence significative entre les groupes HA et RSA (p = 0,11)

Conclusion : En utilisant une technique chirurgicale optimisée, avec des implants conçus pour les fractures, la RSA peut être la première option dans la prise en charge des fractures complexes de l'extrémité proximale de l'humérus chez les patients âgés de plus de 60 ans.

Discipline : Chirurgie orthopédique et traumatologique

Mots clés : hémiarthroplastie ; prothèse totale d'épaule inversée ; survie ; résultats fonctionnels ; fracture de l'extrémité proximale de l'humérus

Survival and, functional and radiological results of trauma reverse shoulder arthroplasty *vs* trauma hemiarthroplasty with a mean follow-up of 50 months.

Abstract

Background : The aim of the study was, firstly, to compare the functional and radiological outcomes of RSA with HA in elderly patients with acute proximal humeral fractures, secondly to compare the mid-term survival of these two types of arthroplasty.

Method : All patients treated by RSA or HA for acute proximal humeral fracture, in primary hospital center were retrospectively identified. The primary endpoint was absolute and weighted Constant-Murley score. We also performed a statistical survival analysis of Kaplan-Meier.

Results : Forty nine patients were included in the clinical and radiological analysis and 141 patients were included in the survival analysis. At the final follow-up, the absolute Constant Score was higher in the RSA group, but there was no significant difference between HA and RSA groups, respectively 57.4 ± 21.8 *vs* 65 ± 17.1 (p = 0.184). However, the weighted Constant score was clinically and statistically significantly better in the RSA group (HA : 81.16 ± 28.9 *vs* RSA : 108.04 ± 27.6 ; p = 0.001). The estimated mean survival time was 50 ± 6 months in the RSA group and 64 ± 8 months in the HA group. The analysis of the survival curve of Kaplan-Meier did not show any significant difference between the HA and RSA groups (p = 0.11)

Conclusion : By using an optimised surgical technique, with implants designed for trauma, RSA can be the first option in the management of complex proximal humeral fractures in patients older than 60.

Discipline : Trauma and orthopaedic surgery

Keywords : hemiarthroplasty; reverse shoulder arthroplasty; survival rate; functional outcome; humeral fracture