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ORIGINAL ARTICLE

The main cause of instability after unconstrained shoulder prosthesis is soft tissue deficiency

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Background: Instability is one of the major causes of failures in unconstrained anatomic total shoulder arthroplasty (TSA). This study reviewed the instabilities that may occur in an anatomic shoulder platform system to identify its potential predictors. We hypothesized that soft tissue deficiency was the main cause of instability and that the best treatment option would be conversion to a reverse shoulder arthroplasty (RSA).

Materials and methods: Between 2003 and 2013, we reviewed 27 patients who experienced postoperative instability, and the overall incidence was 5.07%. There were 8 hemiarthroplasties (HAs), 14 TSAs with metal-backed glenoid components, and 5 TSAs with cemented glenoid components.

Results: We reported 10 isolated subscapularis tears, 6 massive rotator cuff tears, 8 component malpositions, 2 component dissociations or loosening, and 1 humeral shortening. These dislocations occurred early, within the first 6 months postoperatively, in 20 patients and later in 7. Specific procedures were performed in 8 patients, 17 were converted successfully to a RSA, and no surgery was done in 2 patients. At the last follow-up (mean, 36.96 months) Constant scores, Subjective Shoulder Value, and Simple Shoulder Test scores improved significantly to 49.9, 56.4%, and 6.9 of 12, respectively ($P < .05$). None of the 25 patients who were revised were categorized as failures. Patients who underwent conversion had a better outcome than those who had other specific procedures ($P = .001$).

Conclusion: The major cause of instability in our series was soft tissue deficiency. Most of the patients required conversion, and the platform system we used made conversions easier.

Level of evidence: Level IV; Case Series; Treatment Study

Keywords: Instability; subscapularis; rotator cuff; platform system; total shoulder arthroplasty; conversion

Instability is one of the most commonly addressed complications of unconstrained total shoulder arthroplasty (TSA). In a large cohort series, Wirth and Rockwood[24] reported that horizontal instability occurred in 5.2% of 1496 total

The Ethic Committee of Clinique de l'Union, Saint-Jean, France approved this study.

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Table I Distribution of patients

Variables	HA	TSACG	TSAMB	Total
	(n = 117)	(n = 156)	(n = 273)	(N = 546)
	No. (%)	No. (%)	No. (%)	No. (%)
Patients lost to follow-up	1	7	6	14 (2.56)
Remaining patients for the study	116	149	267	532
Patients with shoulder prosthesis instability	8 (6.89)	5 (3.35)	14 (5.24)	27 (5.07)
Glenoid dysplasia (type B, C, or anterior defect)	4/8 (50)	1/5 (20)	9/14 (64)	14/27 (51.8)

HA, hemiarthroplasty; *TSACG*, total shoulder arthroplasty cemented glenoid component; *TSAMB*, total shoulder arthroplasty metal-backed component.

shoulders. In a meta-analysis, Bohsali et al[1] found a prevalence of 4.9% of unconstrained TSA instability (superior, 3%; posterior, 1%; and anterior, 0.9%). With an unconstrained shoulder prosthesis, instability can occur in any direction or combination of directions and can happen early or late after the procedure. Instability is rarely the result of a serious traumatic event. The commonly described causes are quite specific. These typically include any or all of incorrect component positioning in height or version, or both, at the time of surgery, improper component sizing, soft tissue imbalance, neurologic damage, or implant loosening.[9,15,16,24]

In such a situation, specific revision procedures can be proposed, depending on the causes of the prosthetic instability, such as repositioning or resizing the component, bone block procedures, and soft tissue repairs, with variable and unpredictable results.[9,15,18,24] Another option is the conversion from an anatomic to a reverse shoulder arthroplasty (RSA), especially when there is a rupture of the subscapularis along with a posterosuperior cuff tear. This situation can lead to an anterosuperior escape of the humeral head, which is a truly devastating complication.

Since 2003, we have been using a completely convertible shoulder platform system with the advantage of easier and less cumbersome revisions (Arrow; FH Orthopedics, Mulhouse, France). This system has a universal humeral stem with both metal-backed (MB) and cemented (CG) options for the glenoid implant. During conversion to a reverse prosthesis, the surgeon can remove the humeral head and implant a metallic tray with a polyethylene bearing without removing the humeral stem. If the glenoid implant is a noncemented MB device, the conversion is easier by only removing the polyethylene shell, leaving the well-fixed glenoid baseplate, which will support the glenosphere.

A good understanding of the causes for instability after shoulder arthroplasty is essential to prevent such complications at the time of surgery and to efficiently manage the problem if it does occur postoperatively. Only a few studies have reported the results, advantages, and complications of such a completely convertible shoulder system .[3,10]

We hypothesized that the incompetence of the soft tissue surrounding the prosthesis—especially the rupture of the subscapularis tendon—was the main cause of instability of unconstrained shoulder platform systems and that conversion would be the best treatment option. The main purpose of this study was to review our patients with instability after anatomic shoulder prosthesis to identify its potential predictors. The secondary purpose was to report the clinical and radiologic results of our revision procedures in a retrospective study of 27 patients.

Materials and methods

This is a retrospective case-control study of 546 primary anatomic shoulder arthroplasties performed by the 3 senior surgeons of our group (D.K., J.K., and P.V.) at 3 different institutions between 2003 and 2013 (Table I). Written information forms and consents duly signed by the patients were obtained before the surgical procedure. There were 273 TSAs with ingrowth MB glenoid (TSAMB) components, 156 TSAs with CG (TSACG) components, and 117 hemiarthroplasties (HAs). The study excluded 14 patients who were lost to follow-up within 3 months; hence, the study cohort comprised 532 patients.

We retrospectively analyzed all patients who had a postoperative instability of their shoulders after an anatomic shoulder arthroplasty performed during this interval. The patients who developed instability after acute trauma on the operated shoulder were excluded as unrelated to the surgical procedure. Any shoulder with a confirmed infection identified preoperatively or intraoperatively was excluded. According to our infection departments, a minimum of 5 cultures in each revision case was performed to rule out a possible low-grade infection. All cultures at our institutions were held for 14 days to assess for *Propionibacterium acnes*.

Postoperative instability was diagnosed in 27 patients (21 women, 6 men), which represents 5.07% of the cohort. Patients were a mean age of 66.3 years (range, 42-83 years) at the time of the index surgery. The indications were malunion after primary osteoarthritis (OA) of the shoulder in 13, OA after recurrent anterior dislocation of the shoulder in 6, acute 4-part proximal humeral fracture in 3, proximal humeral fracture in 2, post-traumatic OA in 2, and posterior instability after an open Latarjet procedure in 1. The right shoulder was implicated in 22 patients and the dominant side in 26.

Prior surgery (index procedure)

No patient had undergone prior surgery in the shoulder at the time of the index procedure except 1 patient who had undergone a Latarjet procedure for traumatic anterior instability (Table II). All index procedures were performed with the patient semiupright or supine with

Table II Patient demographics and study outcomes

Patient	Age (y)	Sex	Indication for index surgery	Walch glenoid type	Initial prosthesis	Cause of instability	Direction of instability	Timing of dislocation (mo)	Treatment	FU	Constant	SSV	SST	Subjective satisfaction
1	77	F	OA	B1	TSAMB	Incorrect version H and G	Posterior	1	Conversion	16	**59**	60	8	Much better
2	81	F	OA	B2	TSAMB	SScp rupture	Anterior	18	Conversion	12	60	70	8	Much better
3	79	F	OA	B2	TSAMB	Incorrect version H and G	Posterior	1	Conversion	12	68	70	8	Much better
4	76	F	OA	B2	TSAMB	SScp rupture	Anterior	3	Conversion	36	33	30	2	Same
5	83	F	OA	B2	TSAMB	SScp rupture	Superior	22	Conversion	18	55	50	5	Better
6	45	F	Malunion	A2	TSAMB	G loosening	Superior	1	Conversion	18	45	50	5	Better
7	69	F	OA	B2	TSAMB	SScp rupture	Posterior	1	Conversion	60	73	75	10	Much better
8	63	F	OA	C	TSAMB	SScp rupture	Posterior	1	Conversion	36	69	70	9	Much better
9	73	M	OA	C	TSAMB	PE dissociation	Superior	1	Conversion	48	48	50	5	Better
10	42	M	PL	A1	TSAMB	Incorrect version G	Anterior	3	Conversion	16	65	65	8	Much better
11	64	M	OA	B2	TSACG	Axillary palsy, incorrect version G	Posterior	1	Reduction, conversion	34 (died)	73	70	9	Much better
12	76	F	LAD	A2	TSACG	SScp rupture	Anterior	3	No surgery	18	32	30	2	Same
13	71	F	LAD	A2	TSACG	Massive RCT	Posterior	84	Reduction	109	20	25	1	Same
14	65	F	OA	A2	TSACG	SScp rupture	Anterior	1	Suture SScp	132	42	40	4	Better
15	51	M	OA	A2	TSAMB	Incorrect version G	Superior	3	G revision	39	90	85	12	Much better
16	65	F	Malunion	A2	TSAMB	Malposition G	Superior	6	G revision	36 (lost)	45	45	4	Better
17	75	F	LAD	A1	TSAMB	Massive RCT	Superior	120	Conversion	24	25	30	2	Same
18	70	F	OA	B2	TSAMB	Incorrect version G	Posterior	3	Conversion	37	57	60	8	Much better
19	60	F	OA	A1	TSACG	Massive RCT	Superior	24	Conversion	48	62	60	9	Better
20	73	F	PTOA	A1	Hemi	Massive RCT	Anterior	1	No surgery	28	34	30	2	Same
21	73	F	LAD	AGBL	Hemi	SScp rupture	Anterior	1	Bone block	36 (died)	21	25	10	Same
22	63	F	LAD	A1	Hemi	SScp rupture	Anterior	1	Bone block	60	43	40	4	Better
23	65	F	Fracture	A1	Hemi	Incorrect version H	Anterior	6	H revision	18	21	25	1	Same
24	59	F	PTOA	A1	Hemi	H length	Inferior	1	Conversion	20	62	60	8	Much better
25	53	F	LAD	AGBL	Hemi	SScp rupture	Anterior	3	Conversion	12 (lost)	46	50	5	Better
26	60	M	Fracture	A1	Hemi	Massive RCT	Superior	24	Conversion	60	55	50	7	Better
27	59	M	Fracture	A1	Hemi	Massive RCT	Superior	24	Conversion	18	65	65	8	Better

AGBL, anterior glenoid bone loss; *F*, female; *FU*, follow-up; *G revision*, glenoid component revision; *H revision*, humerus component revision; *hemi*, hemiprosthesis; *LAD*, locked anterior dislocation; *M*, male; *OA*, (primary) osteoarthritis; *PE*, polyethylene; *PL*, post-Latarjet; *PTOA*, post-traumatic osteoarthritis; *RCT*, rotator cuff tear; *SScp*, subscapularis; *SST*, Simple Shoulder Test; *SSV*, Subjective Shoulder Value; *TSACG*, total shoulder arthroplasty cemented glenoid component; *TSAMB*, total shoulder arthroplasty metal-backed component.

a sand bag below the interscapular region. All procedures were performed under interscalene block and general anesthesia for a better postoperative pain relief. A standard deltopectoral approach was used. A subscapularis peel was performed in 21 of 27 patients to allow medial translation of the transosseous reinsertion when passive external rotation was limited, a subscapularis tenotomy in 3 patients, and the lesser tuberosity—with the inserted subscapularis—was repaired in the 3 patients with acute trauma. The condition of rotator cuff at the time of the index surgery was normal or repairable (partial or distal supraspinatus tear) according to clinical, radiologic, and intraoperative data. A tenodesis of the long head of the biceps into its groove was performed in every patient. Fourteen patients underwent TSAMB, 5 underwent TSACG, and eight underwent hemireplacements (Table II).

After humeral preparation, the trial stem was placed to protect the humeral cut while the glenoid was prepared. The glenoid side was exposed with a capsular release and clearing of the labrum. Great care was taken to visualize the limits of the glenoid vault because the preoperative computed tomography scan could evaluate osteophytes and glenoid version. The ancillary system allowed accurate reaming and preparation of the glenoid for a press-fit keel groove to ensure a perfect contact between the glenoid component and the bone. Special attention was paid to find the perpendicular glenoid vault axis. In patients with type B or C glenoids according to the Walch classification,[22] correction of the glenoid retroversion was attempted to recreate the native glenoid version.

An asymmetric anterior reaming was performed alone when there was no risk of severe compromise of the healthy bone stock. When this was not the case, a combination of anterior reaming and posterior bone graft was performed. Cancellous bone graft from the humeral head was placed posteriorly onto the microperforated underlying glenoid bone. In this latter situation, an MB glenoid component was preferred to a CG to prevent a possible risk of thermal necrosis of the graft during cementation. No compensatory anteversion of the humeral component was performed to prevent any posterior instability.

The MB glenoid component thickness was 6.5 mm, 3.5 mm for the polyethylene component (PE), and 3 mm for the metallic tray. The deep convex surface and the keel were hydroxyapatite coated. Strong primary fixation was ensured by 2 (5.5-mm-diameter) cancellous screws axially and could be enhanced by a third sagittal screw.

There were 9 type A1, 6 A2, 1 B1, 7 B2, and 2 C glenoids according to the Walch classification,[22] and there were 2 with anterior glenoid bone loss in chronic and locked anterior dislocations. In 6 B2 and 2 C patients (30%), severe glenoid erosion existed, and cancellous bone graft was added under the MB glenoid baseplate.

The humeral stems were press-fit in 21 shoulders (77%), and bone from the humeral head was grafted into the medial part of metaphysis to avoid varus deviation of the stem. In the remaining 6 shoulders, the metaphyseal bone was osteoporotic or fractured, and the humeral stem had to be cemented. The humeral component was always implanted in 20° of retroversion, irrespective of the type of glenoid dysplasia. Careful transosseous repair of the subscapularis was performed in all shoulders.

Timing of instability

The mean interval between the index procedure and the treatment for instability was 13.26 months (range, 1-120 months; Table II). The time duration of instability was termed as "immediate" in 12 patients (dislocation or subluxation occurred within 1 month after the index surgery), 8 patients were "early dislocators" (dislocation occurred between 1 and 6 months), 5 were "late dislocators" (dislocation occurred between 6 months and 2 years), and 2 were grouped as "very late dislocators" (dislocation occurred at or after 2 years).

Revision surgery for instability

All revisions were performed through the previous deltopectoral approach with patients in the beach chair position under general anesthesia and interscalene block (Table II). This deltopectoral approach allowed a distal extension of the exposure in case of stem replacement. Adhesions at the deep part of the deltoid and the conjoint tendon were carefully released. The intact subscapularis tendon was peeled off from the medial border of the bicipital groove to obtain sufficient length for a tension-free reinsertion. In this situation, the version/height of the stem and of the glenoid component were analyzed to identify a possible malpositioning and were corrected when needed. The quality of the fixation of the glenoid baseplate and the humeral stem were systematically evaluated. The subscapularis tendon was medialized and reinserted transosseously. When a tear of the subscapularis or supraspinatus muscle, or both, was the cause for instability, a conversion from an anatomic to an RSA was performed.

Cause of instability: operative data

The cause for instability was identified as subscapularis rupture in 10 patients (torn and retracted at the level of the glenoid or impossible to identify to allow its reinsertion; Table II). A massive rotator cuff tear (RCT) was found in 6 patients. A malpositioning of the components was the cause in 8 patients (incorrect version of both components in 2, glenoid malpositioning in 5, and humeral malpositioning in 1). A MB glenoid loosening was responsible for instability in a patient who had sustained an intraoperative fracture at the index surgery. There was dissociation of the PE from the MB in 1 patient and an excessive shortening of humerus in 1 patient. The direction of instability was identified as anterior in 10 patients, superior in 9, inferior in 1, and posterior in 7. One transient and immediate postoperative axillary nerve injury occurred after the index procedure, which was not the cause of the instability. Dislocations were "immediate" or "early" in 20 patients: 8 with a rupture of the subscapularis tendon, 8 with an error in the implant orientation, 1 with a PE/MB dissociation, 1 with a MB loosening (intraoperative glenoid fracture at the index surgery), 1 with a transient nerve palsy, and 1 with a humeral shortening. Five patients were classified as "late dislocations," and were all related to a massive RCT.

Prosthetic component

The Arrow convertible system is a platform system whereby the humeral stem and the glenoid MB baseplate are the same regardless of the type of arthroplasty. During conversion, the anatomic head of the humeral implant was disconnected from the stem and removed. A circumferential capsular release was systematically performed. In cases of a MB glenoid component, the PE glenoid onlay was then unlocked from the baseplate. A CG component was switched to an

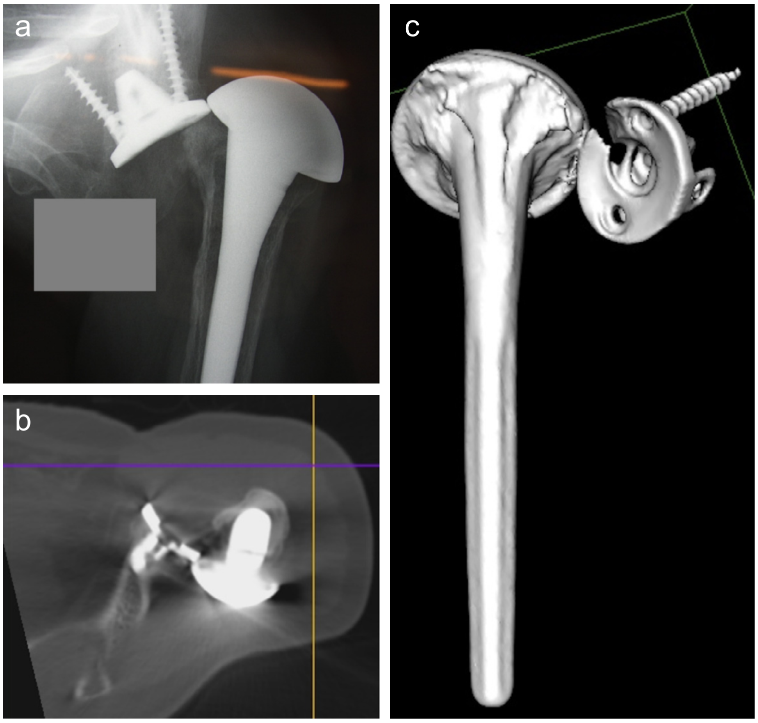

Figure 1 (**A**) Plain x-ray image and (**B**) computed tomography (axial view) show posterior total shoulder arthroplasty dislocation. (**C**) A 3-dimensional computed tomography reconstruction is shown of panel **B**.

MB glenoid component. In this latter challenging situation with severe glenoid bone loss, an iliac crest cancellous bone graft was implanted along with a long peg MB component. A glenosphere was impacted on the baseplate, and a PE humeral bearing was then implanted on the humeral stem. Intraoperative stability of the implant was assessed looking for any posterior, anterior, or superior impingement.

Treatment of instability

Of the 27 patients identified with instability, 2 were reduced successfully without surgical intervention (Table II). One of these patients, who had undergone successful closed reduction, dislocated during the early postoperative period as a result of transient axillary nerve palsy. He required a conversion at a later date for recurrent instability caused by an associated glenoid component malpositioning. The remaining patient had dislocation 81 months postoperatively with a massive RCT. Specific revision procedures were performed in 6 patients, which included 2 bone blocks, 2 CG component repositioning, 1 humeral stem recementing (wrong version), and 1 subscapularis tendon repair. Eighteen patients needed a conversion to a RSA (Figs. 1 and 2). In 2 of those 18 conversions (11.1%), reduction of the RSA was impossible or considered to be too tight even after extensive soft tissue release and resection of the remaining supraspinatus tendon. Hence, the stems (1 cemented and 1 uncemented) had to be replaced in a lower position by minimal humeral shortening to allow reduction. For the cemented stem, a humeral osteotomy was mandatory for implant removal, and a new cemented stem was implanted in the correct position after reconstruction of the humerus using cerclage wiring. Removal of the uncemented stem was possible without osteotomy and, hence, was replaced with a new uncemented stem in the correct position. Two patients were not treated because of the high risk of anesthesia.

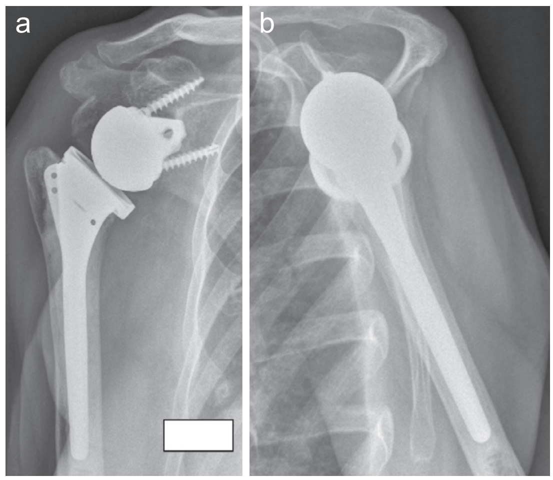

Figure 2 (**A and B**) Plain x-ray images of the same patient after conversion from total shoulder arthroplasty.

Postoperative management

All patients were admitted to the hospital on the day before surgery and were discharged 2 days after surgery if medically fit. No physiotherapy occurred during the postoperative hospital stay to prevent an immediate postoperative dislocation. A sling was given for 4 weeks postoperatively, and an outpatient physiotherapy was started following the Kany platform system[10] protocol. A systematic double-antibiotic therapy was initiated, which was stopped when cultures were negative in more than 3 samples.

Clinical evaluation

Patients were evaluated postoperatively at 3 weeks, 3 months, 6 months, and at 1-year intervals thereafter. Clinical evaluation included visual analog scale (VAS) pain scores, function, range of motion (ROM), and strength, assessed by the senior authors, and outcomes were rated according to the Constant score,[4] the Subjective Shoulder Value (SSV),[13] and the Simple Shoulder Test (SST).[7] Preoperative and postoperative values were compared. Shoulder stability was also evaluated. Patient satisfaction was graded subjectively according to a 4-point rating scale as much better (4), better (3), same (2), and worse (1).

Radiologic evaluation

Patients were evaluated before the index surgery with a standard anteroposterior (AP) view and a computed tomography scan to evaluate the glenoid type according to the Walch classification[22] and the status of the cuff.

Postoperative x-ray images of the shoulder were also performed at each visit. A standard AP view in neutral, internal, and external rotation and an axillary lateral view were routinely taken to evaluate component migration or subsidence. In TSA and HA, superior translation was evaluated on a standard AP view in neutral rotation. Anterior and posterior migrations were similarly evaluated on an axillary lateral view. Component loosening was identified according to the radiolucency around the glenoid and humeral components.[19,20] Radiographs of RSAs were evaluated with special reference to scapular notching and fractures of the acromion or spine of the scapula.

Statistical method

The primary objective was to understand the significance of soft tissue imbalance on the prosthetic instability. A regression analysis was undertaken to determine whether soft tissue imbalance predicted the instability. For statistical analysis, the cause for instability was converted into categoric data (intact cuff vs. deficient cuff) based on clinical and radiologic findings at the initial evaluation and the preoperative Constant, SSV, and activities of daily living scores were considered as covariates that predicted instability.

The secondary objective of the analysis was to understand whether the revision surgical procedure significantly influenced patient outcomes at the maximal follow-up period. The analysis compared the mean differences in functional outcomes, such as active range of motion, Constant score, SSV score, and pain during movements, at the maximal follow-up compared with the preoperative status. The Wilcoxon signed rank test was used to test the statistical significance of this difference. A nonparametric test was chosen because our patients were not assigned randomly to the operative procedures. As a tertiary analysis, we compared the Constant scores of patients who underwent a conversion procedure compared with the other procedures. An independent statistician using SPSS 20.0 software (IBM, Armonk, NY, USA) performed the statistical analyses.

Results

Clinical outcomes

The mean duration of follow-up between the revision procedure for instability and the most recent clinical follow-up was 37 months (range, 12-132 months). Two patients were lost to follow-up (12 months and 36 months, respectively) after the revision surgery, without any recurrence of prosthesis instability at the last follow-up. Two patients died of causes unrelated to the surgery (34 and 36 months respectively after the revision surgery, with no recurrence of instability).

Active range of motion was significantly improved. Active flexion increased significantly from a mean 82° (range, 30°-150°) to 108° (range, 10°-170°). Active external rotation with the elbow at the side increased significantly from 13° (range, −10° to 60°) to 29° (range, −10° to 70°) and with the arm held in 90° of abduction from 30° (range, 0°-20°) to 45° (range, 0°-90°). Mean pain in the Constant score improved from 3 to 12 points (P = .001). The VAS improved significantly from 6 to 2. The mean Constant score improved from 26 (range, 2-50) to 51 (range, 20-90). The mean SSV improved from 25% (range 10%-50%) to 52% (range, 25%-85%). The mean final SST was 6 "yes" (Table III).

Table III Statistical analysis of outcome measures

Outcomes	Mean ± SD	95% CI	Significance (P value)
Pain			.001
Pre-op	6.1± 0.8	5.8-6.5	
Follow-up	2.5± 1.8	1.9-1.9	
Active range of motion			
Flexion			.027
Pre-op	82.2±28.3	71.0-93.4	
Follow-up	105.7±39.7	90.0-121.5	
Abduction			.003
Pre-op	71.5±28.2	60.3-82.6	
Follow-up	103.7±35.7	88.6-118.4	
ER1			.007
Pre-op	14.1±14.4	8.4-19.8	
Follow-up	28.1±20.1	20.2-36.2	
ER2			.083*
Pre-op	30.0±22.0	21.3-38.7	
Follow-up	42.0±24.5	32.4-51.7	
Constant score			.001
Pre-op	26.3± 8.4	22.9-29.6	
Follow-up	50.7±18.2	43.5-57.9	
SSV Score			.001
Pre-op	24.6± 7.8	21.5-27.7	
Follow-up	51.1±17.5	44.2-58.0	

CI, confidence interval; *ER1*, external rotation with arm at the side; *ER2*, external rotation with the shoulder abducted to 90°; *SD*, standard deviation; *SSV*, Subjective Shoulder Value.

* Mean difference was not statistically significant.

Subjectively, 10 patients rated their shoulders as much better, 10 as better, and 7 as same as preoperatively. Of these 7 patients who rated their shoulder as "same," 2 had had a conversion, 1 had undergone a bone block procedure, and 1 had had closed reduction. The remaining 2 could not undergo surgery due to high risk for anesthesia. None of them rated their shoulder as worse.

Radiologic outcomes

No periprosthetic lucency or shift in the component were observed at the last follow-up. There was no scapular notching. No fracture of the acromion or the scapular spine were observed in the cases of conversion.

Complications

One patient, in whom the hemi-Arrow prosthesis was converted to a RSA after a failed closed reduction, dislocated again 2 years later because of a shortening of the humerus. A second revision was successful with a thicker cup on the humeral side. Except for this patient, no patients had instability or infection, and none of the 27 shoulders was categorized as a failure.

Analysis of the results

The global incidence of unconstrained convertible shoulder arthroplasty instability was 5.07% (Table IV), and was 5.24% for the TSAMB, 3.35% for the TSACG, and 6.89% for the HA. Type B2 and C glenoid dysplasia were noted in 15.8% of the HA, in 6.3% of the TSACG, and in 23% of the TSAMB during the index procedure.

In the TSAMB group, 64.3% (9 patients) of instabilities resulted from soft tissue failure, and 35.7% (5 patients) were caused by glenoid component malpositioning knowing that all of those patients had Walch type B2 or C glenoid. In the TSACG group, there were 2 (40%) shoulders with anterior instability, 2 (40%) with posterior instability, and 1 (20%) with superior instability, and there was 1 type B1 glenoid in this group.

In the HA group, 2 patients (22.2%) had anterior glenoid bone loss, along with massive RCT in 1 and subscapularis tendon tear in the other leading to anterior instability. In the remaining 6 patients, 3 (33.3%) had a massive RCT, 1 (11.1 %) had subscapularis tendon tear, and 2 (22.2%) had humeral component malposition/shortening.

In the TSACG group, 2 patients (40%) had a massive RCT, 2 (40%) a subscapularis tear leading to anterior instability, and 1 (20%) an incorrect CG version leading to posterior instability.

Although we found soft tissue imbalance was a major cause of prosthetic instability, the linear regression analysis undertaken to predict the prosthetic instability based on the causes (intact vs. deficient cuff) did not reveal a statistically significant relationship between soft tissue imbalance and prosthetic instability ($R^2 = .13$, $F_{(3,23)} = 1.103$, $P = .368$). Nevertheless, soft tissue imbalance was present in 16 of 27 patients (59.3%; Table IV).

With a significance level set at .05, a P value <.05 obtained with this test for all the parameters, except external rotation with the shoulder at abducted to 90°, indicates that the surgical procedure significantly enhanced the functional outcomes of all the patients (refer to specific P values in Table III).

The final Constant score was compared between the patients with a conversion procedure and the patients with specific procedures. Both groups significantly improved compared with their initial assessments, but subgroup analysis of the scores revealed that the conversion group had a better outcome (25.9 ± 8.8 preoperatively vs. 56.7 ± 13.1 at follow-up) that was statistically significant ($P = .001$) compared with the patients who underwent other procedures (27.0 ± 8.0 preoperatively vs. 38.7 ± 28.8 at follow-up, $P = .065$). Direct comparison of the Constant scores at the follow-up revealed a clinically significant difference between the groups (56.7 ± 13.1 for conversion vs. 38.7 ± 28.8 for other procedures), although the mean difference was not statistically significant ($P = .109$; Table V).

Table IV Distribution and percentage of soft tissue imbalances in patient groups

Group (n = 27)	TSAMB	TSACG	HA	Total
Soft tissue imbalance, No.	6	4	6	16
Other causes, No.	8	1	2	11
Total, No.	14	5	8	27
Patients with soft tissue imbalance, %	42.9	80	75	59.3

HA, hemiarthroplasty; *TSACG*, total shoulder arthroplasty cemented glenoid component; *TSAMB*, total shoulder arthroplasty metal-backed component.

Discussion

Instability after TSA is one of the most frequent causes for reoperation after primary and revision arthroplasty.[21] Bohsali et al[1] published a meta-analysis of 33 studies and 2540 TSAs, among which they isolated 124 instabilities (4.9%) and 32 RCTs (1.3%). Within a 10-year period since 2003, we reported 27 of 546 patients (5.07%)with postoperative anatomic convertible shoulder prosthesis instabilities. These include instabilities that stemmed from combined complications such as RCT.

Bohsali et al[1] reported 17.7% of anterior, 62% of superior, and 20% of posterior instabilities after unconstrained TSA. They attributed anterior instability to a combination of soft tissue tensioning and component positioning, superior instability to deficiency of the rotator cuff, posterior instability to excessive component retroversion, and inferior instability to a failure to restore humeral length after trauma. The

Table V Comparison of the final Constant score for patients with a conversion procedure and others

Surgical procedure	Patients	Constant score		Significance (*P* value)	
		Pre-op	Follow-up	Over time	Between groups at follow-up
	No.	Mean ± SD	Mean ± SD		
Conversion	18	25.9 ± 8.8	56.7 ± 13.1	.001	.109*
Specific procedure or nothing	9	27.0 ± 8.0	38.7 ± 28.8	.065*	

SD, standard deviation.
* The mean difference not statistically significant.

direction of instability was different in our study and was identified as 37% anterior, 33% superior, and 26% posterior.

Anterior shoulder prosthetic instability has most often been attributed to disruption of the repaired subscapularis tendon[15] and has been linked to inferior outcomes.[2,8,14,17] Options to deal with the subscapularis tendon during the primary procedure include plain tenotomy, subscapularis tendon peeling, and lesser tuberosity osteotomy.[6] During our index operations and except for the 3 traumatic cases, subscapularis muscle peeling was done in 21 of 27 patients and subscapularis tenotomy in the remaining 3 patients with a transosseous reinsertion. Nevertheless, the most frequently identified cause for instability in our study was subscapularis tendon rupture (10 of 27). In addition, 6 patients were found to have a massive RCT at the time of the revision surgery. One argument is that a glenoid MB component, which is thicker than a CG component, could lead to subscapularis or massive rotator cuff tendon rupture, or both, and consequently to anterior instability or to a devastating anterior-superior escape of the humeral head.[23] Our incidence of instability was actually higher for the TSAMB (5.24%) than for the TSACG (3.35%; Table I). However, we reported B2 and C glenoid in only 6.3% of TSACG vs. 23% of TSAMB during the index procedure.

Indeed, our technical option since 2003 to address retroverted and biconcave glenoids has been to restore a more neutral glenoid surface with a posterior bone graft and implantation of a MB glenoid component, although this was a technically more demanding procedure.[12] Inability to correct posterior glenoid Walch B2 or C deformities with regular CG components has been associated with high rates of loosening whichever technique had been used: augmentation with polymethylmethacrylate cement to fill the posterior defect or bone grafting, which may lead to thermal necrosis during cementation.[5]

Soft tissue failure in our study may have been caused by an overstrain of the soft tissue during correction of posterior subluxation in 4 of 9 patients (Table I). Those results highlight that the amount of bone block to be placed to prevent a posterior instability from happening has to be quantified. However, soft tissue failures (massive cuff or subscapularis tears) were more frequent in the TSACG group (80%) and in the HA group (75%) than in the TSAMB group (42.9%), which suggests the 3-mm MB thickness was not the cause of soft tissue imbalance (Table IV). Statistical correlation between the type of glenoid at the index surgery and its role in causing soft tissue insufficiency could not be performed because of the small number of patients in each glenoid type. This is a limitation that we would like to acknowledge. The most frequent rate of soft tissue deficiency in the TSA and HA groups may be explained by the most frequent cases of locked anterior dislocations with anterior glenoid bone defect before the index procedure (Table I). Katz et al[11] showed that despite a small radiologic lateralization compared with the normal contralateral side (0.36 cm, $P = .02$), the TSAMB clinical results after 2 years were similar to the published TSACG implants series but without any radiolucent lines, glenoid loosening, or joint narrowing.

Sanchez-Sotelo et al[18] showed that more than one-half of the shoulders remained unstable despite attempts of revision. All of the shoulders in our study were stable at the most recent follow-up. Eighteen patients of the 27 shoulders were treated by a conversion to a RSA, with a final Constant score of 57. However, 9 patients who had specific open procedures, such as bone blocks, humeral or glenoid component revision, subscapularis repair, reduction, or nothing, had a final Constant score of 39. This result could be explained by the fact that the universal Arrow platform system did not need revision of both the stem and the glenoid base plate component to switch from a TSA to a RSA (15 of 17 shoulders) or a soft tissue repair.

Finally, 11 unconstrained prostheses sustained episodes of prosthetic instability without any rotator cuff deficiency, whereas 16 unconstrained prostheses had an isolated subscapularis tendon tear (10) or a massive RCT (6). Consequently, we do think that the main cause for unconstrained prosthesis instability was soft tissue deficiency and not component malpositioning, especially in the case of TSACG or HA. This platform system with a cementless glenoid had the advantage of preservation of bone stock, reconstruction of glenoid bone loss if any and easier revision.[10]

Our study had several limitations. The prospective cohort is small, and because of the long study period in elderly patients, there were losses to follow-up, deaths, and variations in follow-up times. Moreover, the comparisons are difficult between the different techniques because of the disparity in the number of patients in each group. Our main purpose was to report the instability incidence of an unconstrained platform shoulder system to analyze predictors.

Conclusion

Soft tissue deficiency was the main cause of unconstrained convertible shoulder prosthesis instability in our study, especially the subscapularis tendon deficiency, followed by the malpositioning of the glenoid component. As a clinical relevance, the treatment led us most often to a conversion from a TSA to a RSA. As opposed to previous studies, we had predictable and reliable results thanks to a platform system that made the revision easier.

Disclaimer

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