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Midterm results of stemless impaction shoulder arthroplasty for primary osteoarthritis: a prospective, multicenter study

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Background: Stemless shoulder arthroplasty using 4 open-fin press-fit anchors has been showing promising short-term clinical and radiographic results for patients' primary osteoarthritis. This prospective, multicenter study presents 5-year postoperative clinical and radiological outcomes of a stemless shoulder arthroplasty for primary osteoarthritis.

Methods: Between November 2012 and December 2015, 100 patients were treated for primary osteoarthritis with the Sidus stem-free shoulder system at 7 European centers. Clinical assessment included the Constant-Murley Score, American Shoulder and Elbow Standardized Shoulder Assessment Form score, Subjective Shoulder Value, and range of motion. True anteroposterior, axial and lateral radiographs were reviewed for osteolysis, glenoid and humerus loosening, heterotopic ossification, radiolucent lines, component migration and humeral bone resorption. In addition to a Kaplan-Meier survival analysis, a comparative analysis between total shoulder arthroplasty and hemiarthroplasty was performed.

Results: Seventy-one patients (36 females) with a mean age of 63.8 years (range: 47-79 years) were available for the 5-year clinical and radiographic follow-up (range: 52-79 months). There was a significant increase ($P < .0001$) in all outcome scores compared to baseline values. Patients with total shoulder arthroplasty (n = 48) achieved significantly better functional outcome than patients with shoulder hemiarthroplasty (n = 23) with regard to the absolute and relative Constant-Murley Score, American Shoulder and Elbow Standardized Shoulder Assessment Form score, and Subjective Shoulder Value as well as greater abduction strength and range of motion in forward elevation and external rotation ($P \leq .004$). There were no cases of osteolysis or humeral loosening. There were some cases of heterotopic ossification (1.4%), radiolucency around the humerus (1.4%) or glenoid (25%), glenoid migration (2.1%), inferior osteophytes (1.4%) or humerus bone resorption (9.9%). The 5-year survival was 94%.

Conclusion: Patients treated with the Sidus stem-free shoulder system for primary osteoarthritis continue to achieve good clinical and radiographic results without any signs of aseptic humeral implant loosening at 5 years postsurgery.

Institutional review board/ethics committee approval was granted by the following institutions: Ethikkommission, Ethikausschuss 4, Charité—Universitaetsmedizin Berlin, Berlin, Germany (No. EA4/021/13), Ethikkommission des Landes Oberoesterreich, Linz, Austria (No. B-38-12), Menistére de L'Enseignement Supérieur et de la Recherche, Paris, France (No. 12.513), Freiburger Ethikkommission International, Freiburg, Germany (No. CME2012-01E), South East Scotland Research Ethics Committee 02, Edinburgh, UK (No. 12/SS/0154), and Segreteria Comitato Ethico Sperimentazione Clinica, Firenze, Italy (No. CME2012-01E).

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Table I
Inclusion criteria.

The patient is aged 18-80 years.
The patient is skeletally mature.
The patient has severe shoulder pain and disability requiring unilateral or bilateral hemiarthroplasty or total shoulder arthroplasty based on physical examination findings and medical history.
Conservative treatment has failed.
The patient meets the following indication: osteoarthritis.
The patient is willing and able to cooperate with the required postoperative therapy.
The patient is willing and able to complete scheduled follow-up evaluations as described during the informed consent process.
The patient has participated in the informed consent process and signed the ethics committee-approved "informed consent" form.

Table II
Exclusion criteria.

The patient is unwilling or unable to give consent or to comply with the follow-up program.
The patient has any condition that would, in the judgment of the investigator, place the patient at undue risk or interfere with the study. Any patient who is institutionalized, is known to abuse drugs, is known to have alcoholism, or cannot understand what is required of him or her is excluded.
The patient is known to be pregnant or breastfeeding.
The patient meets 1 of the following contraindications:
Soft or inadequate humeral bone (including osteoporosis and extensive avascular necrosis or rheumatoid arthritis) leading to poor implant fixation
Metaphyseal bony defect (including large cysts)
Posttraumatic tuberosity nonunion
Signs of infection
Irreparable cuff tear
Revision from failed stemmed prosthesis
Charcot shoulder (neuroarthropathy)

Since stemless implants were first introduced in 2004,[26] there has been a steady increase in stemless anatomic shoulder arthroplasty.[8,37] The stem-free method has proven to be a reliable treatment option with good clinical function and high patient satisfaction for primary osteoarthritis (OA) as well as secondary forms of osteoarthritis including posttraumatic, postinfectious and instability-induced OA.[19,21,23,38] These newer implants offer several advantages including decreased surgical time with lower blood loss,[7,20] less stress shielding,[19] less risk of a diaphyseal stress riser,[6,9] less lateralization,[25,32] and greater bone preservation,[7,11,20,21] which facilitate a simplified revision when indicated and the potential conversion to reverse shoulder arthroplasty with new convertible implants.

The Sidus stem-free shoulder system (Zimmer Biomet, Warsaw, IN, USA) is a metaphyseal anchored prosthesis with excellent short-term clinical and radiological results.[27] In comparison to a historical control group of stemmed humeral implants, the stemless system was found to have a similar clinical success rate of 87% (vs. 85%) based on a 2-year composite endpoint of an improved American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form score (ASES), no radiological signs of radiolucency and migration or subsidence, and no device-related severe adverse events and revisions or reoperations during follow-up.[3] The need for mid- to long-term data was emphasized to confirm recent findings as well as the importance of increasing the clinical data on stemless implants in general. The aim of this institutional review board—approved, prospective multicenter study was to evaluate the 5-year postoperative clinical and radiological results of this stemless implant in primary OA patients.

Materials and methods

Study population

Between November 2012 and December 2015, 148 patients (151 shoulders) with primary or secondary OA were treated with the Sidus stem-free shoulder system at 9 European institutions. This analysis focuses only on included patients who were treated for primary OA (126 shoulders). Initially, all patients met the inclusion (Table I) and exclusion criteria (Table II) and provided written consent for study participation. Of the 9 institutions included in the short-term follow-up study,[27] 2 withdrew their participation from this investigation due to logistic reasons, leaving 26 patients unable to comply with the extended follow-up program. Therefore, these patients were excluded from this midterm evaluation, which included a total of 100 patients.

Implant description, surgical technique, and postoperative rehabilitation protocol have already been published.[27]

Clinical evaluation

Patients were assessed before (baseline) and during surgery as well as at the postoperative time points of 6 months, 1 year, 2 years, and 5 years.

All patients were evaluated based on the absolute as well as age- and gender-modified Constant-Murley Score (CS), the ASES, and Subjective Shoulder Value (SSV).[12,16,31] Abduction strength was measured, pain was assessed using the CS scale of 0-15 points (15 = no pain; 0 = excruciating pain), and patient satisfaction was also evaluated at each follow-up examination. In addition, active range of motion (ROM), including anterior forward elevation, internal rotation, and external rotation at 0° and 90° abduction was documented.

Radiographic evaluation

Preoperative radiographic assessment was made on standardized true anteroposterior (AP), axillary, and Y-view radiographs. Humeral and glenoid defects, bone quality, glenoid morphology according to Walch,[5,39] and fatty infiltration of the rotator cuff[18] were determined on computer tomography scans. In cases of unclear rotator cuff status, an additional magnetic resonance image was performed and assessed.

Five-year postoperative radiographic assessment was performed again using true AP, axillary, and Y-view images to identify osteolysis, loosening (in terms of subsidence or shift in position), heterotopic ossification according to Brooker et al,[10] the development of (inferior) osteophytes,[35] and component migration. Furthermore, bone-implant interface was evaluated for bone resorption and radiolucency lines (RLLs) in millimeters[14] in 10 different humeral zones on AP and axillary views (Fig. 1) and in 3 glenoid zones as outlined by Lazarus et al.[28]

Adverse events

All intraoperative and postoperative surgery and implant-related complications were documented as adverse events within the follow-up period of 5 years.

Survival analysis

Implant survival was described using a Kaplan-Meier survival curve using revision as endpoint.

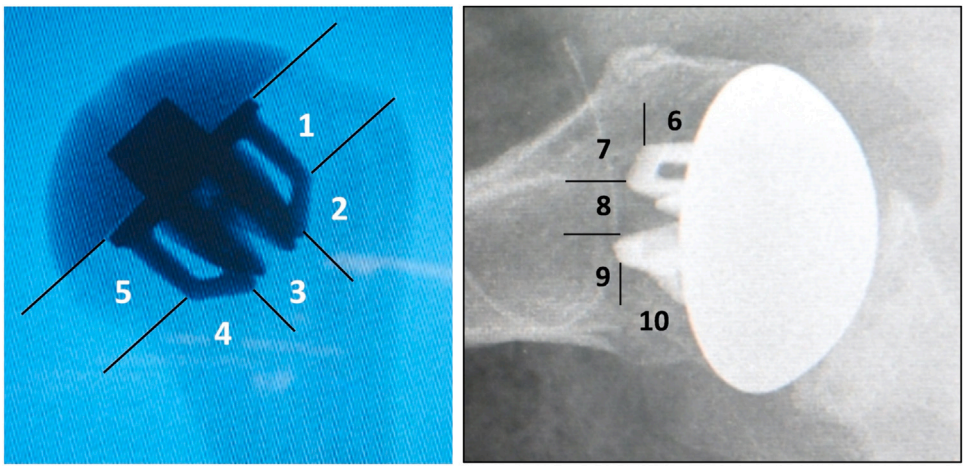

Figure 1 Ten zones at bone-implant interface for radiographic evaluation and classification of osteolysis, radiolucent lines, and bone resorption in true anteroposterior and axial radiographs (classification by Zimmer Biomet).

Table III
Baseline demographics and distribution based on arthroplasty type and glenoid classification for stemless shoulder arthroplasty patients.

Baseline characteristics	HSA	TSA	Total	*P* value*
n (women in %)	23 (35%)	48 (59%)	71 (51%)	
Age at surgery (years), mean ± SD (range)	64.5 ± 9 (47-79)	63.2 ± 8 (48-79)	63.6 ± 8 (47-79)	
Glenoid classification†				.0283
A1	10	16	26	
A2	5	10	15	
B1	0	8	8	
B2	5	14	19	
C	3	0	3	

HSA, shoulder hemiarthroplasty; *SD*, standard deviation; *TSA*, total shoulder arthroplasty.
*Fisher's exact test.
†According to Walch et al.[39] for patients with a 5-year follow-up.

Table IV
Comparison of clinical scores and range of motion at baseline vs. 5-year follow-up.

Clinical outcome measurements	Baseline, mean ± SD (range)	5-year FU, mean ± SD (range)	*P* value*
Absolute CS (points)	26.7 ± 12.2 (10-79)	72.5 ± 15 (20-98)	<.0001
Relative CS (%)	34.7 ± 15.4 (13-104)	95.2 ± 20.9 (21-138)	<.0001
ASES score (points)	37.4 ± 18.4 (6.7-80.0)	87.0 ± 15.5 (22.7-100.0)	<.0001
SSV (%)	35.1 ± 17.7 (0-85)	84.5 ± 13.5 (30-100)	<.0001
Pain scale (0 = excruciating pain; 15 = no pain)	5.7 ± 3.5 (0-15)	13.9 ± 2.3 (4-15)	<.0001
Abduction strength (kg)	0.6 ± 1.9 (0-12.5)	6.0 ± 4.0 (0.5-20.0)	<.0001
Range of motion			
Anterior forward elevation (°)	89 ± 27 (40-170)	153 ± 23 (70-180)	<.0001
External rotation in 90° abduction (°)	14 ± 19 (−20 to 60)	58 ± 20 (10-90)	<.0001
External rotation in 0° abduction (°)	13 ± 16 (−10 to 60)	41 ± 18 (0-80)	<.0001
Internal rotation (CS points)	2.6 ± 2.3 (0-8)	7.0 ± 2.0 (2-10)	<.0001

ASES, American Shoulder and Elbow Standardized Shoulder Assessment; *CS*, Constant-Murley Score; *FU*, follow-up; *SD*, standard deviation; SSV, Subjective Shoulder Value.
*Paired *t*-test.

Data management and statistical analysis

All data were collected on case report forms and uploaded to the Oracle Clinical Remote Data Capture system, Release 5.2.2 (Oracle Corporation, Redwood Shores, CA, USA).

Statistical analysis was performed using SAS Version 9.4 (SAS Institute, Cary, NC, USA). Patient demographics, glenoid status, and functional parameters were tabulated using standard descriptive statistics. Paired *t*-tests were performed to compare pre- and post-operative functional scores. Comparative analyses were also made between total shoulder arthroplasty (TSA) and hemiarthroplasty (HSA) patients, those with concentric vs. posterior glenoid deformities as well as those with and without ipsilateral shoulder surgery using the Wilcoxon rank-sum test. For the radiographic analysis, unpaired *t*-tests were used. The Fisher's exact *t*-test was used to assess the preoperative distribution of glenoid deficiency. The significance level was set to 0.05.

Results

Seventy-one patients (35 males, 36 females) with a mean age of 63.8 years (standard deviation: 8; range: 47-79 years) were available for the 5-year clinical and radiographic follow-up. The average follow-up occurred at 61 months (range: 52-79 months). Of 71 patients, 63 patients (89%) were examined after at least 60 months; however, in 8 cases, a follow-up of up to 9 months

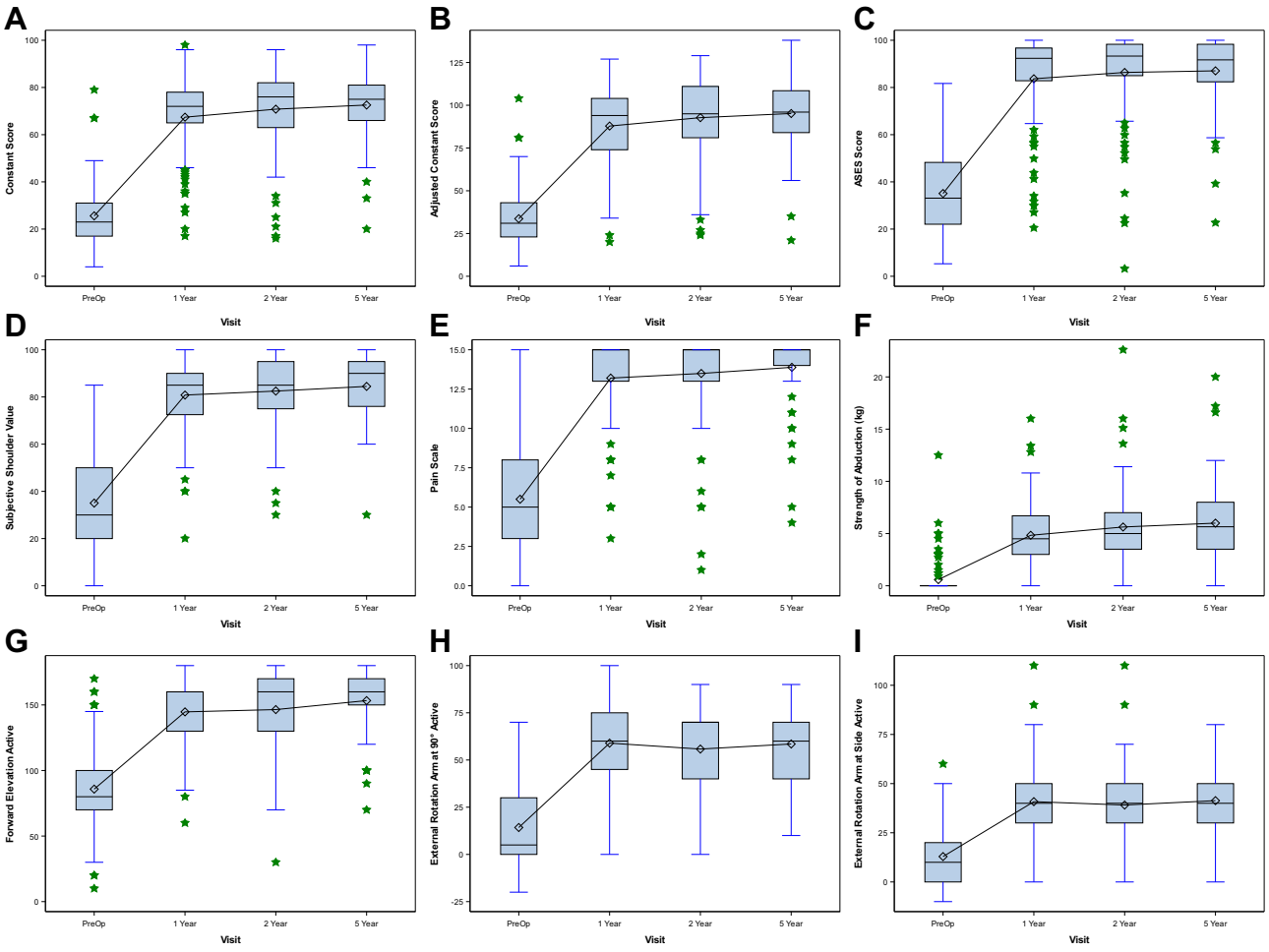

Figure 2 Functional outcome with respect to baseline, 1 year, 2 years, and 5 years postoperatively for the absolute (**A**) and relative (**B**) Constant Score, American Shoulder and Elbow Standardized Shoulder Assessment Form score (**C**), Subjective Shoulder Value (**D**), pain (15 = pain free, 0 = excruciating pain) (**E**), abduction strength (**F**), forward elevation (**G**), and external rotation in 90° abduction (**H**) and with arm at side (**I**).

earlier was performed due to logistic reasons. Drop out of the 5-year analyses occurred due to death (n = 5), loss to follow-up (n = 15), withdrawal from this clinical study (n = 3), and device explantation (n = 6). The reasons for explantation are outlined further below because these events were considered as "adverse events."

Of the 71 patients available for midterm evaluation (Table III), 16 had undergone previous ipsilateral shoulder surgery, including rotator cuff repair (n = 4), capsulolabral repair or reconstruction (n = 1), or subacromial decompression and débridement (n = 11). There were no significant differences comparing patients with and without previous ipsilateral surgery with regard to preoperative or postoperative function at 1, 2, or 5 years.

Functional results

There was a significant increase ($P < .001$) in all clinical outcome scores as well as ROM compared with baseline (Table IV) at 5 years postsurgery; this trend increased steadily until the 2-year examination and reached a plateau by 5 years (Figs. 2 and 3). The majority (91.5%) of patients were satisfied (n = 11) or very satisfied (n = 54) with their shoulder function at 5 years compared with 6 remaining patients who were either somewhat satisfied (n = 3) or did not answer this question at all (n = 3).

The subgroup analysis of shoulder function showed that TSA patients achieved significantly better functional outcomes over HSA patients with regard to the absolute and relative CS, ASES, and SSV ($P \leq .001$) as well as abduction strength and greater ROM in forward elevation and external and internal rotation ($P \leq .0105$; Table V). Satisfaction was also significantly greater for TSA patients at 5 years (Table VI). In addition, patients with posterior glenoid erosion tended to have slightly better functional results, although this trend was not statistically significant (Table V).

Radiographic results

There were no cases of osteolysis or loosening of the humerus anchor reported in our cohort at the 5-year postoperative follow-up.

There were single cases each of Grade 1 heterotopic ossification, development of an inferior osteophyte (<3 mm), and RLL around the humerus in Zones 1 (3 mm) and 2 (2 mm). None of these radiographic changes were associated with impaired shoulder function.

Glenoid-associated RLLs were documented in a quarter of all patients treated with TSA in this follow-up period (12/48). Of these 12 patients, 5 patients had RLL, which were initially observed at the 6-month follow-up that were no longer apparent at the 5-year examination. They did not show impaired function. Those 7

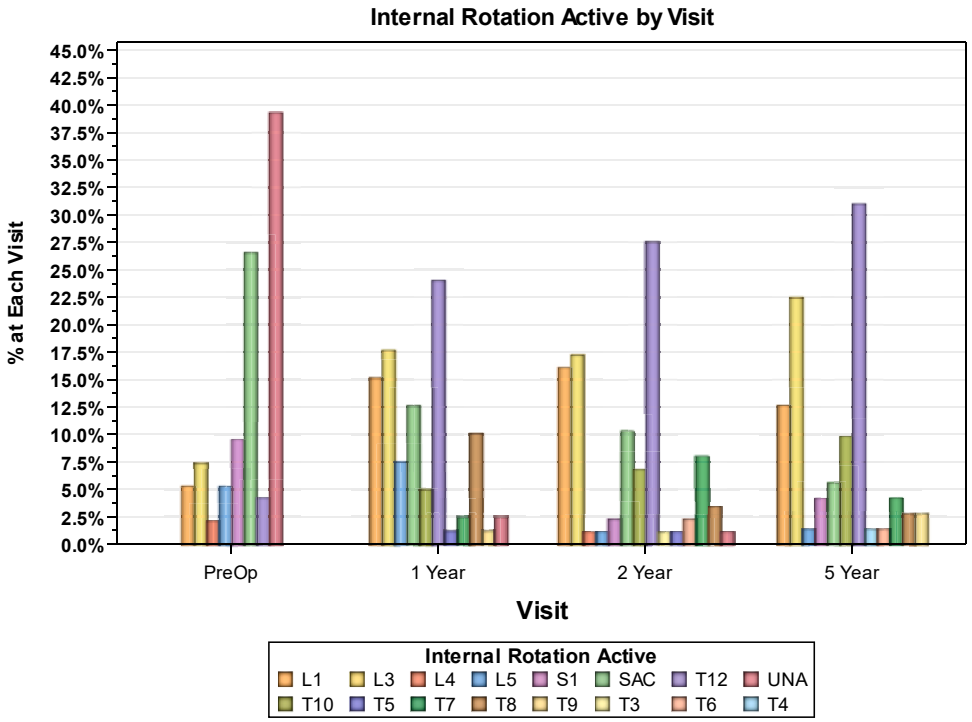

Figure 3 Internal rotation with respect to baseline, 1 year, 2 years, and 5 years postoperatively.

patients with persistent glenoid RLL at midterm had significantly worse modified CS ($P = .029$), ASES ($P = .042$), SSV ($P = .049$), and active ($P = .028$) and passive ($P = .048$) external rotation in 90° abduction.

Only one patient (2.1%) was reported with glenoid migration (<5 mm) at 5 years but did not indicate any functional impairment based on a relative CS of 85%, ASES score of 92 points, and an SSV of 80%.

In 7 patients (9.9%), bone resorption around the humerus was documented at the 5-year examination (Table VII): Bone resorption according to Lazarus et al correlated with lower clinical outcome in absolute ($P = .037$) and relative ($P = .040$) CS, SSV ($P = .021$), active forward elevation ($P = .005$), external rotation in 90° abduction ($P = .043$), and with arm at side ($P = .018$) as well as in strength of abduction ($P = .53$).

Adverse events

Four intraoperative adverse events were noted in our cohort: One patient showed an intraoperative fracture of the greater tuberosity caused during anchor placement who did not need further treatment because there was no dislocation and the anchor was well fixed. Two anchors had to be exchanged intraoperatively for larger ones because of unstable fixation due to diminished bone quality. The fourth patient experienced partial temporary paresis of the brachial plexus that could be treated conservatively.

Postoperatively, 2 patients with HSA were converted to TSA due to shoulder pain and glenoid erosion, one of which had to be revised to a stemmed implant due to persistent pain and functional deficit since their first follow-up visit. The second HSA patient underwent conversion to a TSA, which involved leaving the anchor in situ while replacing the humeral head and resurfacing the glenoid. Another 4 patients (2 TSA and 2 HSA) underwent conversion to a reverse shoulder arthroplasty. Patients with HSA were converted due to rotator cuff insufficiency (n = 2) with additional glenoid erosion (n = 1), whereas 1 patient with TSA was converted to RSA due to pseudoparalysis after a traumatic posterosuperior rotator cuff tear. One patient (TSA) was revised due to infection. This resulted in a complication rate of 8.5%, leading to revision. All revisions are summarized in Table VIII.

Kaplan-Meier survival

As shown in Figure 4, the Sidus stem-free shoulder system had a survival rate of 94% (confidence interval: 87%–98%) after 5 years with revision as the endpoint.

Discussion

The Sidus stem-free shoulder system shows very good midterm results for patients with primary OA. All clinical and patient-rated outcomes measured in our study improved significantly between baseline and the 5-year follow-up. More than 90% of our patients were satisfied or very satisfied with the procedure at midterm, and the complication rate for this stemless implant was 8.5%, with a total survival rate for the humeral anchor of 94%.

Numerous studies show that stemless implants achieve the same clinical results as stemmed implants in case enough metaphyseal bone stock is available for proper fixation[1,7,13,17,30,33]; this factor helps to avoid stem-related complications such as periprosthetic fractures, loosening, or stress shielding. A finite element study demonstrated that stemless humeral implants are better at distributing trabecular force and mimic cortical stress in a near identical manner to that of a native joint, and far better than short-stem or standard stemmed implants.[34]

Although short-term results are promising, pertinent mid- to long-term follow-up data for stemless implants so far focus on 3 implants that have been assessed for 5 or more postoperative years.[6,27,33] The Biomet Total Evolutive Shoulder System (T.E.S.S.) has an 8-year survival rate of 93.5%, and satisfactory long-term

Table V
Comparison of 5-year clinical results for HSA vs. TSA as well as for concentric vs. posterior glenoid defects.

	5-year FU, mean ± SD (range)					
	HSA (n = 23)	TSA (n = 48)	*P* value*	A1, A2† (n = 41)	B1, B2, C† (n = 30)	*P* value*
Absolute CS (points)	59.3 ± 15.9 (20-83)	78.5 ± 9.4 (5-68)	<.0001	72.1 ± 16.3 (20-96)	73.3 ± 12.2 (48-98)	.74
Relative CS (%)	77.1 ± 21.3 (21-109)	103.3 ± 14.9 (79-138)	<.0001	94.2 ± 22.8 (21-138)	96.5 ± 18.1 (61-138)	.98
ASES score (points)	73.7 ± 20.1 (22.7-100)	93.0 ± 7.6 (71.7-100)	<.0001	85.1 ± 18.3 (22.7-100)	89.7 ± 10.6 (53.8-100)	.68
SSV (%)	75.9 ± 15.7 (30-95)	88.1 ± 10.8 (60-100)	.0012	82.7 ± 14.4 (30-100)	87.1 ± 11.9 (60-100)	.18
Pain scale (0 = excruciating pain; 15 = no pain)	12.7 ± 3.4 (4-15)	14.4 ± 1.2 (10-15)	.0587	13.5 ± 2.7 (4-15)	14.4 ± 1.3 (10-15)	.10
Abduction strength (kg)	4.0 ± 3.5 (0-12.0)	6.9 ± 3.9 (1.5-20.0)	.0037	6.5 ± 4.1 (0-20.0)	5.3 ± 3.7 (0.9-17.2)	.14
Range of motion						
Anterior forward elevation (°)	134 ± 28 (70-170)	163 ± 10 (135-180)	<.0001	149 ± 25.5 (70-170)	159 ± 16 (100-180)	.10
External rotation in 90° abduction (°)	43 ± 21 (10-80)	65 ± 15 (30-90)	<.0001	58 ± 20 (20-80)	58 ± 20 (10-90)	.97
External rotation in 0° abduction (°)	29 ± 18 (0-60)	48 ± 14 (20-80)	<.0001	40 ± 19 (0-70)	44 ± 16 (10-80)	.51
Internal rotation (CS points)	6.0 ± 2.1 (2-10)s	7.3 ± 1.9 (2-10)	.0105	7.0 ± 2.0 (2-10)	7.3 ± 1.5 (4-10)	.29

ASES, American Shoulder and Elbow Standardized Shoulder Assessment; *CS*, Constant-Murley Score; *FU*, follow-up; *HSA*, hemi-shoulder arthroplasty; *SD*, standard deviation; *SSV*, Subjective Shoulder Value; *TSA*, total shoulder arthroplasty.
*Wilcoxon rank-sum test.
†According to Walch et al.[39] for patients with a 5-year follow-up.

Table VI
Baseline demographics and distribution based on arthroplasty type and glenoid classification for stemless shoulder arthroplasty patients.

	HSA, n (%)	TSA, n (%)	Total, n (%)	*P* value*
Very satisfied	10 (44%)	44 (92%)	54 (76%)	.0002
Satisfied	7 (30%)	4 (8%)	11 (16%)	
Somewhat satisfied	3 (13%)	-	3 (4%)	
Disappointed	-	-	-	
No data	3 (13%)	-	3 (4%)	

HSA, shoulder hemiarthroplasty; *TSA*, total shoulder arthroplasty.
*Fisher's exact test comparing satisfaction for HSA vs. TSA.

results in 31 patients with a mean CS of 69 points.[4] However, 20 of 22 patients (91%) showed RLL around the glenoid component, 4 of which showed some degree of migration, and the revision rate was 10%. Magosch et al recently published long-term results for the Arthrex Eclipse stemless shoulder prosthesis.[33] Seventy-five patients achieved an average CS of 68 points with a mean follow-up period of 11 years. The 5-year survival rate was 99% and remained high (96.5%) for the stemless humerus component at the 10-year follow-up. Glenoid loosening was reported in 11.4% of the study cohort, and the overall revision rate was 15.1%. There was a trend toward a higher complication rate for TSA over HSA patients. At 5 years, this cohort of primary and post-traumatic OA patients achieved a mean CS of 65 points; the complication rate was 12.8%, with a revision rate of 9%.[19] A multicenter study investigated the Mathys Affinis Short stemless prosthesis in 150 patients with primary OA who achieved a CS of 74 points after 4 years.[24] In the entire heterogenous cohort of 207 patients, 13 (6.3%) required revision surgery, and this revision rate tended to be higher for HSA (9.1%) vs. TSA patients (5.3%).

Current meta-analyses have projected an overall complication rate of 8%-10% with an overall revision rate of 5%-6% for stemless implants.[29,40] Therefore, the Sidus stem-free shoulder system presents comparable midterm functional outcomes and rates of complication and revision to the 3 stemless implants presented in the literature so far.

There was simply 1 patient with RLL around the humerus, which did not affect function with regard to worse ROM or greater pain levels. Therefore, it is safe to say that the humeral component and anchor show no signs of loosening at 5 years (with one being potentially at risk for loosening in the long term).

A study by Alikhah et al has shown that stemless shoulder arthroplasty implants relying on either "press-fit" impaction or screw fixation techniques have been shown to share similar results in terms of clinical and radiographic outcomes.[2] Although medial calcar resorption was documented at a higher rate in patients with the impaction-fitted prosthesis, there were no significant differences in clinical function when compared with patients who were treated with a screw fixation designs.[2] The authors hypothesized that impaction-fitted implants are more prone to medial calcar resorption, whereas the screw fixation prosthesis permits a better load distribution due to its baseplate and constant rim load. Further theories suggest that particles from the breakdown of polyethylene may be responsible for the occurrence of "humeral notching"[33] when there is impingement of the medial calcar against the glenoid component. Further investigation is needed, as this aspect will become immensely important when improved convertible systems emerge and greater focus is placed on bone stock quality at the medial calcar of the humerus.

RLL around the glenoid did, opposed to those at the humerus, affect the function of those patients in our cohort. This finding with our impaction type prosthesis stands in contrast to the midterm results of Heuberer et al[22] using a hollow screw fixation, where neither bone resorption nor RLL did impact clinical function. If RLL were still present at the 5-year follow-up, worse outcomes of the modified CS, ASES score, and SSV as well as decreased active and passive external rotation in 90° abduction can be expected. This may be an early sign of prosthesis micromotion and/or bone remodeling due to stress around the glenoid component, which may either occur because of a greater force and load or due to poor bone stock that compromises stability. Interestingly, patient function was not inferior when glenoid RLL disappeared after 2 years. Hence, persistent RLL around the glenoid at midterm follow-up may indicate glenoid loosening. Long-term follow-up is needed to emphasize this hypothesis. The time frame between 2 and 5 years may be important for integration and bone remodeling around this stemless prosthesis. Glenoid loosening in terms of shift in position, additional migration of the implant or subsidence remains unobserved after 5 years. Although 1 patient showed radiographic glenoid migration (<5 mm) at 5 years, because of its excellent clinical outcome and no RLLs, we have not considered this as loosening.

In a similar manner to stemmed shoulder arthroplasty, patients with glenoid resurfacing show better results in terms of clinical outcomes, pain relief, and subjective satisfaction than patients with HSA. This difference may be the result of glenoid erosion after HSA.

Table VII
Listing of patients and with humeral bone resorption and their clinical outcome.

Patient	HSA/ TSA	Humeral bone resorption zone	Absolute CS (points)	Relative CS (%)	ASES score (points)	SSV (%)	Pain scale (min = 0; max = 15)	Strength of abduction (kg)	Active forward elevation	Active ER with arm at side	Active ER with arm at 90°	Active IR
1	HSA	Zone5	47	73	60,8	70	12	4	100	10	30	L3
2	TSA	Zone1, Zone4, Zone6, Zone7, Zone9, Zone10	68	100	93,7	85	13	2,5	140	50	60	L3
3	HSA	Zone5, Zone10	70	100	92,2	90	14	8	150	50	60	SAC
4	HSA	Zone5, Zone10	20	21	22,7	60	4	1	70	0	.	SAC
5	HSA	Zone5	79	95	100	77	15	8	140	10	20	SAC
6	HSA	Zone5	74	85	83	80	13	8	150	30	40	L3
7	HSA	Zone1, Zone2	71	83	71,7	60	15	4,6	160	35	50	L5

ASES, American Shoulder and Elbow Standardized Shoulder Assessment; *CS*, Constant Score; *ER*, external rotation; *HSA*, hemi-shoulder arthroplasty; *IR*, internal rotation; *L3* = 3rd lumbar vertebra; *L5* = 5th lumbar vertebra; *SAC*, sacrum; *SSV*, Subjective Shoulder Value; *TSA*, total shoulder arthroplasty.

Table VIII
Listing of patients with revision surgery.

Patient	Date of surgery	Date of revision	Implant type	Adverse event	Reoperation procedure
1	July 3, 2013	Decembar 27, 2017	HSA	Shoulder trauma during weight lifting resulting in SSP and ISP tears	Explantation and revision to RSA
2	June 12, 2014	July 14, 2016	HSA	Shoulder pain and glenoid erosion	Conversion to TSA, which involved leaving the anchor intact while replacing the humeral head and resurfacing the glenoid
3	April 9, 2013	August 1, 2013	TSA	Pseudoparalysis after subluxation, resulting in a tear of the superior rotator cuff and superior head migration	Explantation and revision to RSA
4	November 25, 2013	November 2, 2016	HSA	persistent pain and functional deficit since their first follow-up visit	Explantation and revision to a stemmed TSA
5	November 5, 2013	November 7, 2017	HSA	Rotator cuff insufficiency with posterosuperior glenoid defect	Explantation and revision to RSA
6	May 13, 2014	May 14, 2018	TSA	Deep shoulder infection	Explantation, spacer implantation and revision to RSA

HSA, hemi-shoulder arthroplasty; *ISP*, infraspinatus; *RSA*, reverse shoulder arthroplasty; *SSP*, supraspinatus; *TSA*, total shoulder arthroplasty.

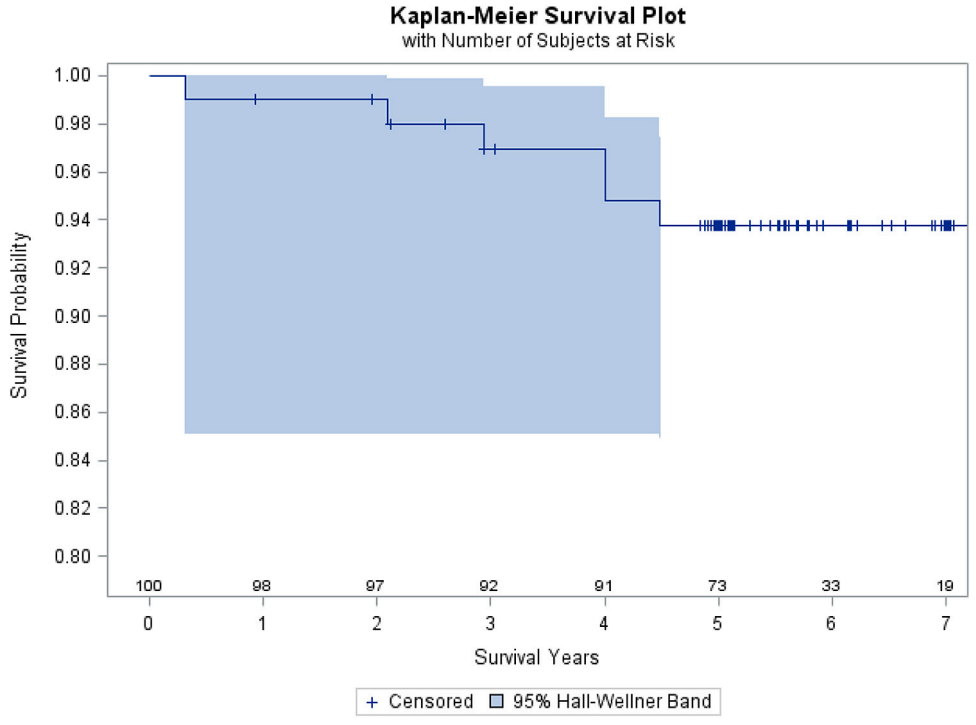

Figure 4 Kaplan-Meier survival curve.

Nevertheless, TSA operations are associated with higher operation times, more blood loss, and higher costs as a primary procedure.[15,36]

Our study incorporates all the advantages that are associated with its multicenter and prospective design. Furthermore, we only included patients with primary OA who were under the age of 80 years, which resulted in a homogeneous cohort. However, this work has several limitations. By presenting the 5-year follow-up outcomes, long-term effects are still outstanding. Our dropout rate of 23% is quite high, although this level of patient loss is comparable to that in the literature (19%-20%) at 5 years.[19,24] Moreover, our multicenter study may, in fact, be a confounding factor based on the heterogeneity in clinical practice and rehabilitation protocols among the participating institutions. A final limitation is the selection bias of patients aged <80 years that potentially exclude those study candidates with poor bone stock.

Conclusion

Patients treated with the Sidus stem-free shoulder system for primary osteoarthritis continue to achieve good clinical and radiographic midterm results without any signs of aseptic implant loosening at 5 years postsurgery.

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