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Anatomic total shoulder arthroplasty with an inlay glenoid component: clinical outcomes and return to activity

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Background: Biomechanical studies show that inlay glenoid components in total shoulder arthroplasty (TSA) can reduce edge loading and opposite-edge lift-off forces with humeral translation compared with onlay glenoids. However, clinical data for these implants are lacking. We report clinical outcomes and return to activities after anatomic TSA with an inlay glenoid component and a stemless ovoid humeral head in an active, young patient population.
Methods: A retrospective review of TSA with an inlay glenoid component and an ovoid humeral head component was performed for 27 shoulders. Patients were evaluated with patient-reported outcome measures, range of motion, and radiographs. Return to occupational and sporting activity, complications, and reoperations were analyzed.
Results: A total of 27 shoulders were available for minimum 2-year follow-up. Age averaged 52.1 years, and 92.6% of shoulders were in male patients. The preoperative Walch grade was A1 or A2 in 15 shoulders (55%), B1 in 8 (30%), and B2 in 4 (15%). Patients showed significant improvements in patient-reported outcome measures, active forward flexion, and external rotation ($P < .001$) with no reoperations. At an average of 3.7 months, the rate of return to work was 92.6%, with 76.0% of those patients returning to their preoperative occupational demand level. At an average of 9.1 months, 75% of patients who responded to our custom survey returned to sport, with 50% achieving the same level or a higher level of sporting activity. Annual postoperative radiographs revealed no inlay component loosening.
Conclusion: Anatomic TSA with an inlay glenoid coupled with a stemless ovoid humeral head in an active population resulted in improved clinical outcomes, no reoperations or radiographic loosening, and a high rate of return to activity at shorter-term follow-up.

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Keywords: Total shoulder arthroplasty; inlay glenoid; stemless humeral component; return to sports; return to work

Total shoulder arthroplasty (TSA) is a successful operation, achieving pain relief and functional improvement in the majority of cases.[21,23] In ‘‘younger,’’ active patients, there is concern about early glenoid wear and loosening, with Denard et al[7] reporting a 38% rate of revision at 10 years owing to glenoid component loosening in patients younger than 56 years at the time of TSA. Along with a longer life expectancy, the high rate of glenoid loosening in younger patients may be related to the fact that over 90% of younger patients return to sporting and occupational activities after TSA, many with moderate to heavy upper-extremity demands.[12,19] Despite these concerns, the demand for TSA in patients younger than 55 years in the United States is projected to grow at a rate of 8.2% per year, for a total increase of 333% from 2011 to 2030. This increase in TSA is coupled with a decline in hemiarthroplasty of 16.5% per year from 2002 to 2011 in patients younger than 55 years.[27] Comparisons of hemiarthroplasty and TSA have revealed superior outcomes for TSA and higher revision rates for hemiarthroplasty because of the need for glenoid resurfacing.[3,29] Bartelt et al[2] reported a series of 46 TSAs and 20 hemiarthroplasties in patients younger than 55 years, finding a 10-year implant survival rate of 92% for the TSA group vs. 72% for the hemiarthroplasty group. Nevertheless, of TSAs with available radiographic follow-up at a mean of 6.6 years, 29.4% showed moderate to severe glenoid lucency or a shift in glenoid position.[2]

TSA glenoid loosening has been described according to the ‘‘rocking-horse’’ phenomenon, in which the humeral head translates on the glenoid, causing edge loading and lift-off forces that lead to loosening.[1,9,22] Recently, an inlay glenoid design has been proposed in which the glenoid component is implanted flush with the adjacent glenoid bone surface. This inlay glenoid design offers the theoretical advantage of less glenoid bone removal to preserve glenoid bone stock, as well as less potential for implant edge loading and lift off owing to the inlay design because the polyethylene edges are flush with or slightly recessed relative to the adjacent glenoid surface.[10] Biomechanical testing and finite element analyses have favored an inlay glenoid design over the traditional onlay glenoid for both implant stability and decreased loosening.[10,15] Clinical outcomes of TSA with inlay glenoids are unknown, with reports limited to small series in which inlay designs were used because of severe glenoid bone deficiency that was not amenable to a traditional glenoid component.[6,14]

The purpose of this study was to report clinical outcomes and return to work and sporting activities after anatomic TSA with an inlay glenoid coupled with an ovoid humeral head component in an active, young patient population. We hypothesized that patients would have significant clinical improvements with a low rate of complications and high rate of return to occupational and sporting activities after undergoing TSA with an inlay glenoid.

Materials and methods

Patient selection

A retrospective review was conducted in a consecutive series of patients undergoing anatomic TSA with an inlay glenoid component and a stemless ovoid humeral head component (Arthrosurface, Franklin, MA, USA), for a diagnosis of primary or post-traumatic glenohumeral osteoarthritis, performed by a single surgeon between February 1, 2014, and March 1, 2017. Prior to TSA, patients underwent nonoperative management including modification of activity and oral anti-inflammatories in all cases. In some cases, patients also underwent physical therapy and/or glenohumeral cortisone injections at a minimum of 3 months prior to TSA. Indications for TSA with an inlay glenoid were young patients (aged < 65 years) with a desire to return to occupational and/or sporting activities that, in the senior author's assessment, would potentially lead to an elevated risk of early glenoid wear and loosening. The exclusion criteria were patients with diagnoses other than primary or post-traumatic glenohumeral osteoarthritis, a concomitant rotator cuff tear, a history of shoulder arthroplasty or hemiarthroplasty, and posterior glenoid wear graded greater than B2 by the Walch classification.

Radiographic assessment

Patients were evaluated preoperatively and postoperatively with radiographs (true anteroposterior, scapular Y, and axillary lateral views). The senior author, a fellowship-trained shoulder surgeon with over 20 years in practice, evaluated the preoperative radiographs to determine the Walch classification of glenoid bone loss.[31] Advanced imaging with magnetic resonance imaging and/or computed tomography was performed preoperatively for evaluation and preoperative planning in all patients. The senior author assessed postoperative radiographs obtained at annual clinical follow-up visits for evidence of osteolysis, radiolucent lines, or change in position of components. An example of preoperative and postoperative radiographs of a patient undergoing TSA with the stemless ovoid humerus and inlay glenoid is shown in Figure 1.

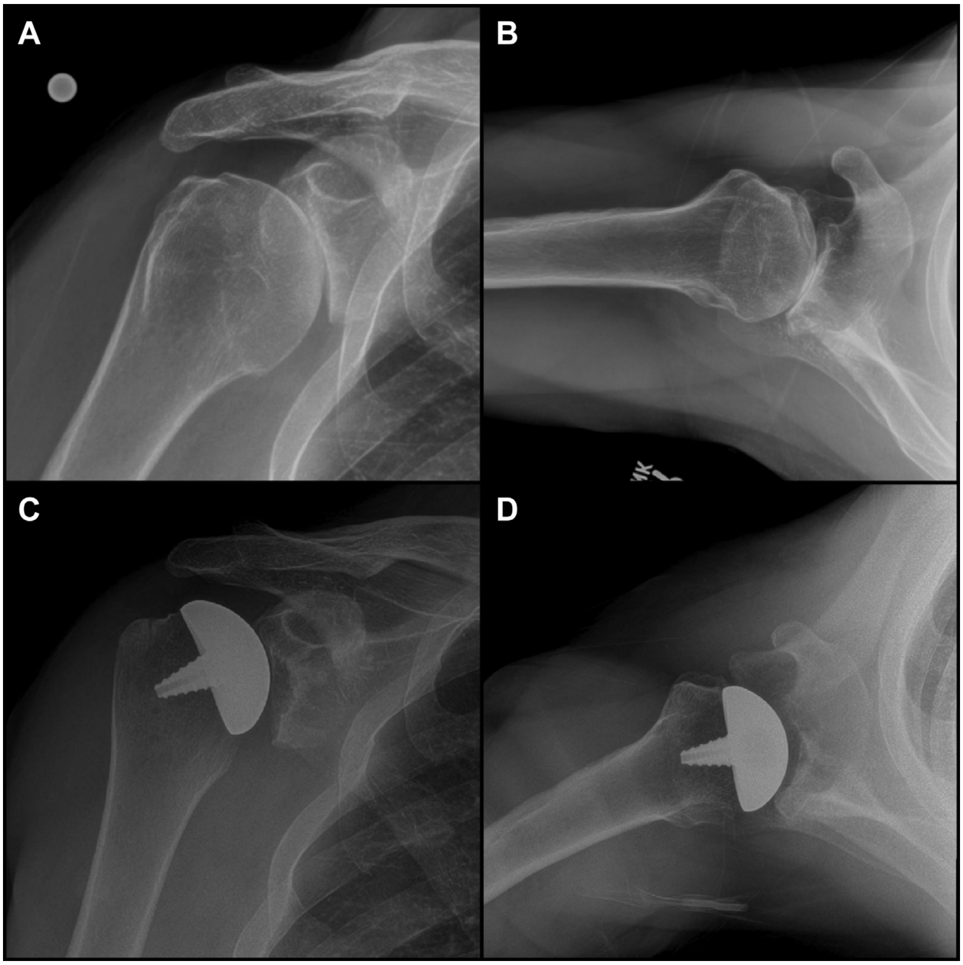

Figure 1 Preoperative anteroposterior (**A**) and axillary lateral (**B**) radiographs show glenohumeral osteoarthritis without significant posterior wear. (**C**, **D**) Postoperative radiographs show total shoulder arthroplasty with stemless humeral resurfacing and inlay glenoid (Arthrosurface).

Surgical technique

The deltopectoral approach is used to perform TSA with a subscapularis tenotomy, 360° subscapularis release, tenodesis of the long head of the biceps tendon, removal of humeral osteophytes, and capsular release to facilitate complete glenoid exposure. For the aspherical ovoid humeral head component, sizing guides are used to determine the anteroposterior and superoinferior dimensions of the humeral head. The system will place a humeral component that is 4 mm less in diameter in the anteroposterior dimension than the measured superoinferior dimension. Thus, the humeral head is ovoid.

The glenoid is exposed, the circular glenoid guide is placed on the center of the glenoid, and the reamer guide pin is placed to the proper depth. The glenoid is reamed over the pin to a stop, thus ensuring the proper depth of the inlay glenoid preparation. Next, the inlay depth guide confirms the depth and position, and a central hole is drilled for the central small peg of the inlay component. An awl is used to create cement holes in the prepared glenoid. Methylmethacrylate cement is placed and pressurized with a silicone finger collette. The inlay glenoid component (Arthrosurface) is impacted into the proper position, and any peripheral excess cement is removed. The goal is to place the component flush with, but not proud to, the native glenoid surface. The backside of the component is stairstepped for a macro-interlock with the cement mantle. An example of a properly placed inlay glenoid component is displayed in Figure 2.

The humeral component is trialed to confirm proper balance, mobility, and stability. Suture holes are placed in the biceps groove for later transosseous subscapularis repair. Finally, the definitive humeral component is placed and impacted over the post. The subscapularis is repaired with a combination of transosseous and tendon-to-tendon nonabsorbable sutures (No. 2 and No. 5 Ethibond; Ethicon, Somerville, NJ, USA), and it is important to note that the rotator interval is repaired with No. 2 nonabsorbable braided sutures.

Postoperative care is not different for a traditional onlay glenoid component, including 4 weeks in a sling with hand, wrist, and elbow motion allowing for activities of daily living. At the first postoperative visit at 1 week, pendulums out of the sling are instituted and formal physical therapy begins. Three phases are performed: 1 month of passive motion; 1 month of active-assisted motion and isometric muscle exercises; and finally, 1 month of active motion, stretching, and resistive exercises for the rotator cuff and scapula. After completion of this program, work- and sport-specific exercises can be instituted.

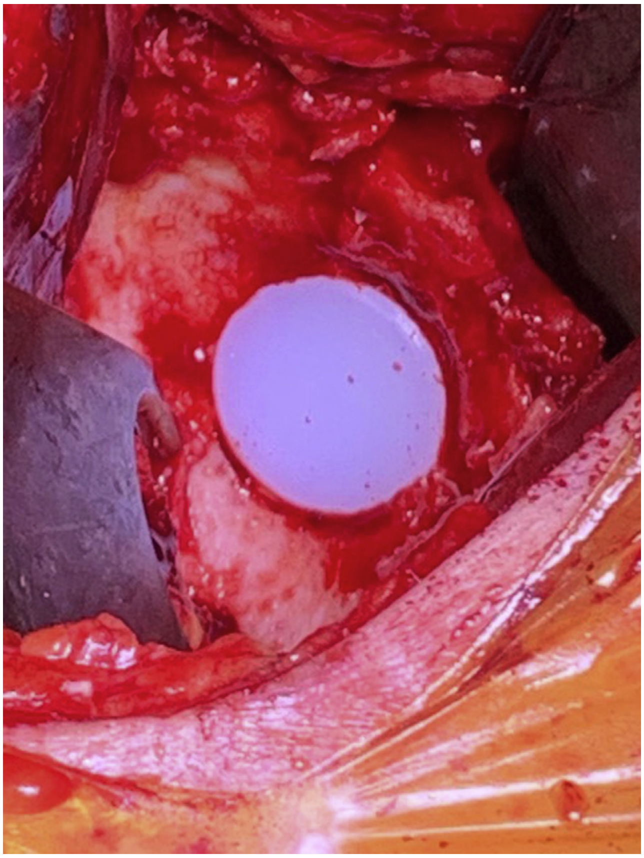

Figure 2 Inlay glenoid component implanted in right glenoid. It is 20 mm in diameter.

Outcomes

Baseline patient characteristics including age, sex, and prior surgical procedures were collected from electronic medical records. Patient-reported outcome measures (PROMs) were collected preoperatively and postoperatively including the visual analog scale score for pain, Single Assessment Numeric Evaluation (SANE) score, American Shoulder and Elbow Surgeons (ASES) score, functional component of the ASES score, and 12-Item Short Form (SF-12) score. The functional component of the ASES score is a 10-item survey grading the ability to perform daily work activities and activities of daily living (unable, very difficult, somewhat difficult, or not difficult), yielding a score from 0 to 30 points. Preoperative and postoperative active forward flexion and external rotation with the arm at the side were obtained via a goniometer as part of the preoperative and postoperative physical examinations performed by the senior surgeon. Complications and reoperations were evaluated.

Patients were contacted by phone to complete a questionnaire (Supplementary Appendix S1) detailing their occupational and sporting demands both preoperatively and postoperatively.[11,13,18] Preoperative occupational demands were classified by intensity of work based on the US Department of Labor classifications (sedentary, light, medium, medium-heavy, or heavy). For patients employed preoperatively, the ability to return to work was assessed along with the timing of return to work and occupational demands postoperatively (sedentary, light, medium, medium-heavy, or heavy). For patients who modified their occupational demand level or retired after surgery, the patient-reported reason for modification or retirement was assessed (shoulder related, other medical causes, patient preference, or other). Patients were asked if they participated in any sporting activities within 3 years prior to surgery. For those who participated in preoperative sporting activities, return to sports was determined if patients returned to at least 1 of their preoperative sports, and the time to return to sports and the level of sports after TSA (same, higher, or lower) compared with the preoperative level were assessed. Finally, patients were asked how satisfied they were with their shoulder in general and with their ability to play sports in particular after TSA.

Statistical analysis

Data analysis was conducted using SPSS software (IBM, Armonk, NY, USA). Statistics were descriptive for patient demographic characteristics and return to occupational and sporting activities. The Fisher exact test was used for categorical variables. Paired *t* tests were used to compare preoperative vs. postoperative values for PROMs and range of motion. Statistical significance was set at $P < .05$.

Results

Patient demographic characteristics

During the study period, TSA with an inlay glenoid component was performed in 27 shoulders in 24 patients and, in all cases, with a stemless humeral component. All 27 shoulders were available for 2-year follow-up (average, 40.4 ± 12.1 months; range, 24-60 months). Patients' average age was 52.1 ± 6.0 years (range, 42-63 years), 92.6% of shoulders (25 of 27) were in male patients, and worker's compensation claimants comprised 11.1% (3 of 27) (Table I). The preoperative diagnosis was glenohumeral osteoarthritis in 23 shoulders (85.1%) and post-traumatic osteoarthritis in 4 (14.9%). The preoperative Walch grade was A1 or A2 in 15 shoulders (55%), B1 in 8 (30%), and B2 in 4 (15%). There were no B3 or C glenoid wear patterns in this series.

Prior surgery on the ipsilateral shoulder had been performed in 40.7% of cases (11 of 27), ranging from 1 to 6 prior surgical procedures. Prior procedures included arthroscopic rotator cuff repair (n = 3), arthroscopic débridement and capsular release (n = 5), subacromial decompression (n = 4), instability procedures (n = 4), biceps tenodesis or tenotomy (n = 3), distal clavicle excision (n = 2), superior labrum anterior-posterior repair (n = 1), and glenohumeral microfracture (n = 2). The patients with prior arthroscopic rotator cuff repair were noted to have good rotator cuff function on examination and an intact rotator cuff at the time of shoulder arthroplasty, so we proceeded with anatomic replacement.

Table I Baseline patient characteristics for TSA with inlay glenoid

	Data
No. of shoulders	27 (3 bilateral)
Age (range), yr	52.1 ± 6.0 (42-63)
Male sex, n (%)	25 (92.6)
Worker's compensation, n (%)	3 (11.1)
Follow-up (range), mo	40.4 ± 12.1 (23-60)
Prior surgery, n (%)	11 (40.7)
Preoperative diagnosis, n (%)	
Osteoarthritis	23 (85.1)
Post-traumatic	4 (14.9)
Walch grade, n (%)	
A1 or A2	15 (55)
B1	8 (30)
B2	4 (15)
B3 or C	0 (0)

TSA, total shoulder arthroplasty.

PROMs, range of motion, and complications

In comparison with preoperative values, significant improvements in the ASES score occurred after TSA, from a mean of 39.5 ± 20.8 preoperatively to a mean of 85.7 ± 16.1 postoperatively ($P < .001$); the functional component of the ASES score, from 9.9 ± 4.7 to 26.3 ± 3.6 ($P < .001$); the SANE score, from 25.1 ± 20.4 to 80.4 ± 13.6 ($P < .001$); the visual analog scale pain score, from 5.4 ± 3.1 to 1.6 ± 2.3 ($P < .001$); and the SF-12 physical score, from 38.1 ± 6.8 to 47.3 ± 10.5 ($P < .001$). No significant difference was found between preoperative and postoperative SF-12 mental scores ($P = .27$) (Table II).

Active range of motion improved in both forward flexion, from a mean of 107° ± 24.5° preoperatively to a mean of 155° ± 16.6° postoperatively ($P < .001$), and external rotation, from 23° ± 7.5° to 55° ± 15.1° ($P < .001$) (Table II). For 17 of 20 shoulders (85%), patients were satisfied or very satisfied with their shoulder after TSA with an inlay glenoid; a single patient, who underwent bilateral TSA and was a worker's compensation claimant, was dissatisfied because of ongoing pain and stiffness after surgery.

No revision surgical procedures were performed in this series. Complications comprised 1 hematoma that resolved without surgery (3.7%) and 1 pulmonary embolism treated with Xarelto (3.7%). Postoperative radiographs obtained at annual follow-up appointments revealed no evidence of osteolysis, radiolucent lines, or a change in position of the inlay glenoid or stemless humeral components.

Return to work and sports

For 20 of 27 shoulders (74.1%), patients responded to our custom return-to-work and -sports survey and completed all questions. Prior to surgery, the occupational demands of all patients who were employed were classified according to the US Department of Labor: heavy in 11 (40.74%), medium in 9 (33.33%), light in 2 (7.41%), and sedentary in 5 (18.52%) (Table III). In 25 of 27 cases (92.59%), patients returned to work at an average of 3.7 ± 5.2 months (range, 0-25 months) postoperatively. Those who did not return to work comprised 1 patient who retired for reasons unrelated to the shoulder and 1 patient unable to return because of back problems. The postoperative occupational demands were the same as those preoperatively in 76.0% of cases (19 of 25), with 6 of those with heavy occupational demands decreasing their work to a lower level. Patients with heavy-demand jobs were less likely to return to work at the same occupational level postoperatively than patients in the other work demand classes ($P = .004$). However, those with heavy-demand jobs were able to return to work at the same rate as patients in all other work demand classes ($P = .146$).

All 20 patients who responded to the custom survey reported participation in some type of sporting activity in the 3 years prior to surgery. The most common sporting activities were weightlifting (9, 33.3%), going to the gym (10, 37.0%), and golf (9, 33.3%). After surgery, 15 of 20 (75% of respondents) were able to return to at least 1 of their preoperative sports at an average of 9.1 ± 4.3 months (range, 3-18 months). Patients with an inability to return to sports attributed it to pain and stiffness in the shoulder in a contralateral case and bilateral case and to lower-extremity problems sustained in a motorcycle crash in a bilateral case. Only 2 patients reported being unable to return to sporting activities because of their shoulder. The rate of return to each specific sport was notable for 77.8% returning to weightlifting, 80.0% returning to going to gym, and 66.7% returning to golf (Table IV). Compared with preoperative sporting intensity, the postoperative level of sports was higher in 4 cases (22.2%), the same in 6 cases (33.3%), and lower in 6 cases (44.4%). In 17 of 20 cases (85.0%), patients stated that their overall physical fitness level was the same as or better than that before surgery. In 16 of 20 cases (80.0%), patients reported being satisfied or very satisfied with their ability to play sports after TSA with the stemless ovoid humeral head and inlay glenoid.

Discussion

Anatomic TSA with an inlay glenoid and stemless ovoid humeral head in a young, active population resulted in improved clinical outcomes at an average of 40.4 months' follow-up. The majority of patients were satisfied with their shoulder; however, only 55% returned to sporting activity at the same level or a higher level. There were no reoperations, and annual postoperative radiographs revealed no inlay component loosening.

Treatment of the young, active patient with advanced glenohumeral osteoarthritis is the subject of considerable

Table II Patient-reported outcome measures and active range-of-motion improvements after TSA with inlay glenoid

	Preoperative	Postoperative	*P* value
ASES score	39.5 ± 20.8	85.7 ± 16.1	<.001
Functional score*	9.9 ± 4.7	26.3 ± 3.6	<.001
SANE shoulder score	25.1 ± 20.4	80.4 ± 13.6	<.001
VAS pain score	5.4 ± 3.1	1.6 ± 2.3	<.001
SF-12 score			
Physical	38.1 ± 6.8	47.3 ± 10.5	<.001
Mental	49.4 ± 13.0	51.8 ± 10.4	.27
Active forward flexion, °	107 ± 24.5	155 ± 16.6	<.001
Active external rotation, °	23 ± 7.5	55 ± 15.1	<.001

TSA, total shoulder arthroplasty; *ASES*, American Shoulder and Elbow Surgeons; *SANE*, Single Assessment Numeric Evaluation; *VAS*, visual analog scale; *SF-12*, 12-Item Short Form Survey.
* Functional component of ASES score, with possible scores ranging from 0 to 30 points.

debate in the literature. Because of glenoid polyethylene wear and loosening concerns, glenoid-sided alternatives to polyethylene have been attempted in shoulder arthroplasty. These have included hemiarthroplasty alone, hemiarthroplasty with reaming of the glenoid, and hemiarthroplasty with soft-tissue interposition. Non-arthroplasty alternatives such as arthroscopy with débridement and capsular release, particularly for milder glenohumeral osteoarthritis with over 2 mm of joint space remaining, have shown some utility.[5,24,25] Attempts to perform "biological" resurfacing of the glenoid in combination with humeral hemiarthroplasty have been reported, but the results have shown unacceptably high failure rates with conversion to TSA in 50% to 70% of patients within 3 years.[28,30]

Shoulder arthroplasty is the primary treatment for the young patient in whom conservative treatment for advanced glenohumeral osteoarthritis has failed. In the short term, TSA in the young patient offers excellent functional improvements, with over 90% of patients reported to be able to return to work and sporting activity, higher than the rate after hemiarthroplasty.[12,19,20] In addition, TSA has been found to result in superior outcomes and lower revision rates than hemiarthroplasty.[3,29] Bartelt et al[2] reported a series of 46 TSAs and 20 hemiarthroplasties in patients younger than 55 years, finding a 10-year implant survival rate of 92% for the TSA group vs. 72% for the hemiarthroplasty group. Nevertheless, there are significant concerns about glenoid component loosening when TSA is performed in young, active patients with higher demands on the shoulder and longer life expectancies. Despite its low reported revision rate, the study by Bartelt et al on TSA revealed a 29.4% rate of moderate to severe glenoid lucency or a shift in glenoid position with radiographic follow-up at a mean of 6.6 years. Denard et al[7] reported a 38% rate of revision at 10 years owing to glenoid component loosening in patients younger than 56 years at the time of initial TSA.

Table III Occupational demand levels, ability to return to work, and ability to return at same occupational demand level

	Preoperative, n (%)	Return to work postoperatively, n (%)	Return to same occupational level, n (%)
Heavy	11 (40.7)	9 (81.8)	3 (33.3)
Medium	9 (33.3)	9 (100.0)	9 (100.0)
Light	2 (7.4)	2 (100.0)	2 (100.0)
Sedentary	5 (18.5)	5 (100.0)	5 (100.0)
Total	27 (100.0)	25 (92.6)	19 (76.0)

The inlay glenoid design offers several theoretical advantages over the traditional onlay glenoid design, as does the aspherical humeral head. The inset or inlay glenoid may not "edge load" on one side and "lift off" on the other side with humeral translation because the polyethylene component lies flush with or slightly recessed relative to the remaining glenoid face.[10,15] This mechanism has been implicated in loosening of traditional onlay glenoids.[1,9,22] Biomechanical and finite element analyses have supported improved mechanical stability and decreased loosening for inlay as opposed to onlay glenoids.[10,15]

There are also theoretical advantages to an aspherical humeral head that translate into better range of motion and more normal forces on the glenoid; thus, decreased glenoid loosening may occur in patients.[4,16,17] The stemless ovoid humerus with the inlay glenoid may ultimately allow the surgeon to be more comfortable with a higher patient activity level after TSA, particularly for younger patients who desire to return to sporting or occupational activities that may place moderate to heavy demands on the upper extremity. In addition, it could provide the proven advantage of polyethylene resurfacing of the glenoid with better short-term results and a higher rate of return to activities compared with hemiarthroplasty alone.

Despite the theoretical advantages and basic science support of the inlay glenoid concept, clinical studies of TSA with inlay glenoids have limited application because of small sample sizes and short follow-up. Egger et al[8] have recently published a series, similar to our study, in which patients underwent inlay glenoid and aspherical humeral head TSA and achieved high activity levels and excellent range of motion. The sex, age, and results of their series are very comparable to those in our study. Gunther and Lynch[14] reported a series of 7 patients averaging 70 years of age with custom inset glenoids for the indication of osteoarthritis with severe glenoid bone deficiency (vault < 15 mm). They reported an ASES score improvement of 68 points with significant improvement in pain and motion in all planes. Implants were "low risk" for loosening at an

Table IV Sports activity participation preoperatively and postoperatively and direct rates of return to each sport after TSA with inlay glenoid

	Preoperative, n (%)	Postoperative, n (%)	Rate of return to specific sport, %
Going to gym	10 (37.0)	8 (29.6)	80.0
Golf	9 (33.3)	6 (22.2)	66.7
Weightlifting	9 (33.3)	7 (25.9)	77.8
Cycling	4 (14.8)	4 (14.8)	100.0
Running	4 (14.8)	2 (7.4)	50.0
Swimming	4 (14.8)	4 (14.8)	100.0
Bowling	3 (11.1)	2 (7.4)	66.7
Basketball	2 (7.4)	1 (3.7)	50.0
Hunting	2 (7.4)	2 (7.4)	100.0
Softball	2 (7.4)	1 (3.7)	50.0
Tennis	2 (7.4)	2 (7.4)	100.0
Yoga	2 (7.4)	2 (7.4)	100.0
Baseball	1 (3.7)	0 (0.0)	0.0
Cross-country skiing	1 (3.7)	1 (3.7)	100.0
Hockey	1 (3.7)	1 (3.7)	100.0
Rock climbing	1 (3.7)	1 (3.7)	100.0
Scuba diving	1 (3.7)	1 (3.7)	100.0
Skydiving	1 (3.7)	1 (3.7)	100.0
Volleyball	1 (3.7)	1 (3.7)	100.0
Wakeboarding	1 (3.7)	1 (3.7)	100.0

TSA, total shoulder arthroplasty.

average of 4.3 years' follow-up. Similarly, Davis et al[6] reported the results of an inlay glenoid in 9 shoulders in 7 patients with an average age of 66 years and a mean follow-up period of 34 months. These cases comprised 6 primary arthroplasties and 3 revision cases, with the inlay glenoid being indicated for patients based on severe glenoid dysplasia or bone loss that made it impossible to place a traditional glenoid component. Davis et al found improved motion in forward flexion and external rotation, as well as significant improvements in pain and the SANE score. In contrast, we report the largest series of clinical outcomes of TSA with an inlay glenoid, performed for the indication of glenohumeral osteoarthritis in young, active patients without significant glenoid deformity. Our patients were younger, were more active, and had less glenoid deformity than those in the 2 prior small series, but we similarly found that shorter-term clinical outcomes at a mean of 40.4 months showed excellent improvements in PROMs and motion without revision or evidence of radiographic loosening of the glenoid. In cases of more significant bone loss in young patients with glenohumeral osteoarthritis, such as those described by Davis et al and Gunther and Lynch, we have preferred to perform TSA with posterior glenoid bone grafting of the glenoid defect using humeral head autograft and a traditional keeled glenoid component.[26] Nicholson et al.[26] reported that 28 patients who underwent standard TSA with posterior glenoid bone grafting had excellent clinical outcomes at an average of 4 years' follow-up, with high rates of graft incorporation and no cases requiring component revision in their population with more severe retroversion deformity.

With younger patients undergoing TSA, they will be more likely to want to return to sporting and recreational activities after TSA.[12,19,20] Using TSA with an inlay glenoid and stemless ovoid humeral head, we found that 83% of patients were satisfied or very satisfied with their ability to play sports and that 55% achieved the same level or a higher level of sporting activity compared with preoperative levels. In a recent systematic review, Liu et al[20] found, similarly to our study, that 92% of patients were able to return to sports after TSA, significantly higher than the rate after hemiarthroplasty (71%).

The strengths of our study include that it is the largest series of TSA using an inlay glenoid component with a stemless ovoid humeral head component to date, with a 74% rate of 2-year follow-up and 100% rate of 1-year follow-up. Early results are presented in detail including analysis of the ability to return to sporting and occupational activities, with analysis by specific occupational demand level and specific sporting activity. Furthermore, the patients had similar indications including a younger age, the desire to return to high-level sporting and/or occupational demands, and the absence of significant glenoid bone loss.

The limitations of the study include selection bias owing to the use of the inlay glenoid implant preferentially in young, active patients without advanced glenoid wear (no B3 or C glenoids in this series), as well as lack of postoperative advanced imaging. Postoperative advanced imaging was not obtained because patients were doing well clinically, and therefore, there was no clinical indication for imaging other than standard postoperative radiographs.

In addition, the study is limited by the fact that the patients only had shorter-term follow-up, averaging 40.4 months. Despite the theoretical and biomechanical advantages of the ovoid humeral head coupled with the inlay glenoid design in decreasing glenoid loosening, mid- and long-term follow-up of this implant in this younger, high-demand population is essential to determine if loosening and revision rates will improve relative to TSA with traditional onlay glenoids.

Conclusion

Anatomic TSA with an inlay glenoid and a stemless ovoid humeral head in a young, active population resulted in excellent range of motion, improved clinical outcomes, no reoperations or radiographic loosening, and a high rate of return to occupational and sporting activity at shorter-term follow-up.

Disclaimer

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Brian R. Waterman is an American Academy of Orthopaedic Surgeons, American Orthopaedic Society for Sports Medicine, and Arthroscopy Association of North America board or committee member; is an editorial board member of the *American Journal of Orthopedics* and *Arthroscopy*; receives publishing royalties and financial or material support from *Arthroscopy* and Elsevier; and is a paid presenter or speaker for Genzyme.

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Supplementary data

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