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Primary Total Shoulder Arthroplasty is Superior to Hemiarthroplasty for the Treatment of Glenohumeral Arthritis: Analysis of 5-year Outcomes in a Large Surgical Database

Jason Long[1], Kunal Varshenya[2], Kier Blevins[1], Julia Ralph[1], Anna Bryniarski[1], Caroline Park[1], Lucy Meyer[1] and Brian Lau[1]

Abstract

Background: Total shoulder arthroplasty (TSA) is the preferred treatment for glenohumeral arthritis refractory to nonoperative measures. However, some surgeons have argued for a role for hemiarthroplasty (HA) in the setting of a smooth glenoid that articulates appropriately with the humeral head. The purpose of this study is to evaluate long-term revision rates and short-term postoperative complications in patients undergoing either HA or TSA for glenohumeral arthritis.

Methods: A retrospective review of patients who underwent HA and TSA was conducted using a commercially available national database. Demographics, postoperative complications, risk factors, revision rates, and costs were analyzed using 2 sample *t*-tests, chi-squared tests, and multivariate logistic regressions.

Results: Patients were stratified by operation: (1) HA (n = 1615) or 2) TSA (n = 7845). Patients undergoing primary TSA had higher rates of prior ipsilateral rotator cuff repair and corticosteroid injections. At 2 years, patients who underwent HA, 3.0% of patients had revision surgery, compared to 1.6% of patients who underwent TSA ($P = .002$); at 5 years, 3.7% of the HA cohort ($P < .0001$) had revision surgery, compared to 1.9% of patients who underwent TSA.

Conclusions: Patients undergoing TSA or RTSA for glenohumeral arthritis had higher preoperative co-morbidities but had no difference in short-term complication rates with a lower risk of revision surgery at both 2-year and 5-year follow-up when compared to HA. Increasing age, female sex, hyperlipidemia, postoperative infection, shoulder instability, and thromboembolism all independently increased odds for revision shoulder arthroplasty for glenohumeral arthritis.

Level of evidence: Level: III.

Keywords

total shoulder arthroplasty, shoulder hemiarthroplasty, reverse shoulder arthroplasty, glenohumeral joint arthritis, rotator cuff injury, hemiarthroplasty outcomes

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Introduction

Glenohumeral (GH) arthritis is a leading cause of shoulder pain in older adults, affecting 20% to 30% of patients older than 60 years old worldwide.[1,2] It is characterized by progressive humeral head cartilage loss, adaptive changes to the subchondral bone, and global biomechanical changes of the GH joint.[3] With a growing ageing population, the incidence of GH arthritis is expected to increase more than 7-fold in 2030.[4] Current surgical treatment options for GH arthritis include total shoulder arthroplasty (TSA), reverse TSA (RTSA), and hemiarthroplasty (HA).

HA, first pioneered by Neer in the 1950s, involves resurfacing the humeral head while leaving the glenoid intact.[5] Initially, Neer described the use of a stemmed prosthesis, however, these implants have evolved

[1]Duke University School of Medicine, Durham, NC, USA
[2]Stanford University School of Medicine, Stanford, CA, USA

Corresponding author:
Julia Ralph, Duke University School of Medicine, Durham, NC, USA.
Email: julia.ralph@duke.edu

significantly to include stemless designs.[6] Recently, HA has fallen out of favor to total arthroplasty as the preferred method to treat GH arthritis, which includes both TSA and reverse TSA (RTSA). Outcomes of TSA and RTSA show a failure rate significantly lower than HA at about 5% at long-term follow up,[7,8] while HA failure rates of 10% to 20% have been reported.[9] Additionally, recent literature suggests TSA to be more cost-effective compared to HA.[10]

Despite high failure rates, HA was traditionally though to be a viable solution for the patient with minimal to no glenoid-sided arthritic changes as a “bridging” procedure that would be converted into a TSA when glenoid arthrosis progressed.[6] With these differences in survivorship and with the growing body of literature demonstrating improved patient satisfaction, functional outcomes and decreased complication rates, recent clinical guidelines have favored total arthroplasty (TSA/RTSA) over HA for the management of the GH arthritis.[3] However, HA is still considered for the young, active patient with intact shoulder function and advanced GH arthritis, as these patients present treatment challenges secondary to the risk of increased total shoulder revision rates at long-term follow-up when undergoing TSA or RTSA.[6,11] The primary purpose of this study was to evaluate the complication and revision rates, risk factors for revision, and cost differences in both younger and older patient populations undergoing HA or total arthroplasty for GH arthritis. We hypothesize that all patients undergoing TSA/RTSA will have lower complication and revision rates, and TSA/RTSA will be more cost-effective compared to HA.

Materials and methods

Data Source

This study obtained a sample of the MarketScan Commercial Claims and Encounters database (Truven Health Analytics, Ann Arbor, MI) from 1/2007 to 12/2016. This database is a collection of commercial inpatient, outpatient, and pharmaceutical claims of more than 75 million employees, retirees, and dependents representing a substantial portion of the US population covered by employer-sponsored insurance. The MarketScan database contains International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) and 10th revision, Clinical Modification (ICD-10-CM), Current Procedural Terminology (CPT), Diagnosis Related Group (DRG) codes as well as National Drug Codes (DEA). Department of Public Health Sciences (PHS) provided the data source for this study.

Patient Selection

This study identified patients who had a primary diagnosis of GH arthritis. The cohort was then filtered to only include patients who underwent either primary HA (CPT 23470) or TSA (CPT 23472) between 2007 and 2015. Only patients with confirmed laterality were included in this study. Due to limitations of CPT coding, the TSA cohort could not differentiate anatomic TSA or RTSA. Patients were excluded if they had incomplete records for up to 2 years or if they had a history of a proximal humeral fracture. Individual demographic information, comorbidity status, and surgical and procedure history of each patient were gathered (Table 1).

Table 1. Demographics and Baseline Comorbidities.

Variables (%)	HA (n = 1615)	TSA/RTSA (n = 7845)	*P* value
Age mean (SD)	**54.9 (7.7)**	**57.9 (5.6)**	**<.0001**
Female (%)	**620 (38.4)**	**3131 (41.8)**	**.0109**
Comorbid status			
Pulmonary disease	**158 (9.8)**	**919 (12.3)**	**.0049**
Diabetes (%)	330 (20.4)	1581 (21.1)	.5377
Hyperlipidemia (%)	**664 (41.1)**	**3742 (50.0)**	**<.0001**
Peripheral vascular disease (%)	**46 (2.9)**	**319 (4.3)**	**.0086**
MI (%)	**25 (1.6)**	**181 (2.4)**	**.033**
Hypertension (%)	**913 (56.5)**	**4772 (63.8)**	**<.0001**
Tobacco use (%)	126 (7.8)	610 (8.2)	.642
Cancer (%)	112 (6.9)	558 (7.5)	.4681
Tissue disorder (%)	38 (2.4)	175 (2.3)	.9713
Congestive heart failure	48 (3.0)	233 (3.1)	.7668
Obesity (%)	**183 (11.3)**	**1185 (15.8)**	**<.0001**
CCI, mean	**0.7 (1.1)**	**0.8 91.2)**	**.0163**
Operative history			
Acromioplasty	70 (4.3)	310 (4.1)	.7213
Rotator cuff repair	**19 (1.2)**	**147 (2.0)**	**.0322**
Biceps tenodesis	9 (0.6)	52 (0.7)	.5206
Corticosteroid injection	**526 (32.5)**	**2989 (39.8)**	**<.0001**

Statistically significant values are indicated in bold.

Abbrebiations: HA, hemiarthroplasty; TSA, total shoulder arthroplasty; RTSA, reverse total shoulder arthroplasty. Bolded values identify statistical significance

Complications

The primary outcome of this study was to determine postoperative complication profiles of patients undergoing HA or TSA/RTSA. The presence of a postoperative complication was defined as a complication occurring within 90 days of the index surgery. These included infection (998.5-998.59, 730.0-730.91, 996.66, 996.67), capsulitis (726.0, 719.51), hematoma (998.1, 998.11, 998.12, 998.13), shoulder dislocation (831.00, 831.09, 718.31, 718.21), nerve injury (955.0-955.9, 907.4), or wound complications (998.3, 998.31, 998.32, 998.81, 998.83, 998.4, 101.40, 101.60, 101.80), deep vein thrombosis (DVT) (451.0-453.9), and pulmonary embolism (PE) (415.1-415.19) (Table 2). Thromboembolism was defined as the presence of either a PE or DVT. Revision shoulder procedures were tabulated and defined by the presence of revision procedure codes (CPT 23473, 23474) occurring after the index surgery date on the ipsilateral shoulder (Table 3). Payment data was also gathered through 5 years of follow-up from index surgery (Table 4).

Statistical Analysis

Patients were stratified into surgical groups based on their index procedure: HA or TSA/RTSA. These groups were mutually exclusive. These patients were then further subdivided into those patients under the age of 50 years old for sub-group analysis. Two sample *t*-tests and Chi-squared tests were utilized to assess significant differences in unadjusted demographic data, and postoperative complications. To minimize the effect of potential confounding on the direct comparison of patients undergoing HA or TSA/RTSA procedures, a multivariate logistic regression controlled for baseline covariates such as age, sex, and comorbidities that had statistically significant differences. (Table 5). An alpha value of 0.05 was set as significant.

Table 2. Postoperative Complications—Within 90 days.

Variables (%)	HA (n = 1615)	TSA/RTSA (n = 7845)	*P* value
Any complication	311 (19.30)	1319 (17.6)	.1202
Stiffness	216 (13.4)	1020 (13.6)	.7881
Shoulder instability	**40 (2.5)**	**117 (1.6)**	**.0105**
Infection	**40 (2.5)**	**101 (1.4)**	**.0009**
Nerve injury	3 (0.2)	12 (0.2)	.8192
Wound complication	5 (0.3)	27 (0.4)	.7529
Deep vein thrombosis (DVT)	16 (1.0)	82 (1.1)	.7113
Hematoma	13 (0.8)	48 (0.6)	.4647

Statistically significant values are indicated in bold.
Abbreviations: HA, hemiarthroplasty; TSA, total shoulder arthroplasty; RTSA, reverse total shoulder arthroplasty. Bolded values identify statistical significance.

Table 3. Revision Arthroplasty Rates.

Variables (%)	HA (n = 1615)	TSA/RTSA (n = 7845)	*P* value
Revision Surgery			
90-days	6 (0.4)	13 (0.2)	.1142
180 days	13 (0.8)	36 (0.5)	.1066
1 year	**31 (1.9)**	**85 (1.1)**	**.0109**
2 year	**49 (3.0)**	**123 (1.6)**	**.0002**
5 year	**60 (3.7)**	**144 (1.9)**	**<.0001**

Statistically significant values are indicated in bold.
Abbreviations: HA, hemiarthroplasty; TSA, total shoulder arthroplasty; RTSA, reverse total shoulder arthroplasty. Bolded values identify statistical significance.

Results

Patient Cohort

A total of 9460 patients were included in the study. Patients were stratified into 2 mutually exclusive groups: (1) HA (n = 1615) or (2) TSA/RTSA (n = 7845). Patients who underwent TSA/RTSA were older on average (57.9 vs 54.9 years-old, $P = <.0001$) and predominantly female (41.8% female vs 38.4% male, $P = <.0109$). Patients who underwent TSA/RTSA had more co-morbidities: Pulmonary disease (12.3% vs 9.8%, $P = .0049$), hypertension (63.8% vs 56.5%, $P = <.0001$), hyperlipidemia (50.0% vs 41.1%, $P = <.0001$), obesity (15.8% vs 11.3%, $P < .0001$) and overall Charlson Comorbidity Index (CCI) (0.8 vs 0.7, $P = .0163$). Patients undergoing primary TSA/RTSA also had higher rates of prior ipsilateral rotator cuff repair (RCR, 2.0% vs 1.2%, $P = .0322$) and corticosteroid injections (39.8% vs 32.5%, $P < .0001$) (Table 1).

Complications and Revision Surgery

In the unadjusted data, there was no significant difference in complication rates at 90 days (TSA/RTSA: 17.6% versus HA: 19.3%, $P = .1202$) (Table 2). At 2 years, the HA

Table 4. Inpatient Payments

Variables (%)	HA (n = 1615)	TSA/RTSA (n = 7845)	*P* value
Day of surgery payments	**$22,959 ($12,663)**	**$27.749 ($14,1290**	**<.0001**
Total payments			
90-day	**$24,926 ($20,261)**	**$29,152 ($16,893)**	**<.0001**
1-year	**$29,377 ($28,534)**	**$34,432 ($29,098)**	**<.0001**
2-year	**$34,422 ($39,584)**	**$39,085 ($38,004)**	**<.0001**
5-year	**$40,138 ($50,810)**	**$43,742 ($49,578)**	**.0016**

Statistically significant values are indicated in bold.
Abbreviations: HA, hemiarthroplasty; TSA, total shoulder arthroplasty; RTSA, reverse total shoulder arthroplasty. Bolded values identify statistical significance.

Table 5. Multivariate Regression Analysis to Identify Risk Factors for Revision Surgery

Parameters	OR	95% CI	*P* value
Baseline variables			
Increasing age	**1.1**	**1.0-1.1**	**<.0001**
Increasing CCI	0.7	0.4-1.9	.3553
Female sex	**1.5**	**1.1-1.9**	**.0032**
Diabetes	0.7	0.4-1.9	.3193
Obesity	**0.6**	**0.4-0.9**	**.0418**
Hypertension	1.1	0.8-1.4	.8638
Hyperlipidemia	**1.4**	**1.1-1.9**	**.018**
Tobacco use	0.8	0.4-1.2	0.2513
Operative history			
Corticosteroid injection	1.2	0.9-1.7	.0829
Any biceps tenodesis	0.4	0.0-1.9	.3589
Any acromioplasty	1.3	0.7-2.2	.3898
Any rotator cuff repair	2.1	0.9-4.1	.0724
Postoperative complications			
Any complication	0.4	0.2-1.2	.1185
Infection	**7.9**	**3.6-16.6**	**<.0001**
Would complication	1.4	0.2-5.9	.692
Stiffness	1.6	0.7-3.8	.2137
Instability	**3.2**	**1.2-7.8**	**.0087**
Thromboembolism	**3.8**	**1.2-10.4**	**.0177**
TSA/RTSA vs. HA	**0.4**	**0.3-0.6**	**<0.0001**

Statistically significant values are indicated in bold.
Abbreviations: HA, hemiarthroplasty; TSA, total shoulder arthroplasty; RTSA, reverse total shoulder arthroplasty. Bolded values identify statistical significance.

cohort had a significantly higher revision rate than TSA (3.0% and 1.6% respectively, $P = .002$) with only 1.9% of patients initially undergoing TSA/RTSA undergoing subsequent revision arthroplasty, compared to 3.7% of the HA cohort ($P < .0001$) (Table 3). In a multivariate regression analysis, increasing age (OR 1.1), female sex (OR 1.5), hyperlipidemia (OR 1.4), postoperative infection (OR 7.9), instability (OR 3.2) or thromboembolism (OR 3.8) increased odds for revision arthroplasty (all $P < .05$). After controlling for all other variables, when compared to patients undergoing primary HA, patients initially managed with TSA/RTSA were significantly less likely to undergo revision arthroplasty (OR 0.4, 95% CI 0.3-0.5, $P < .001$) (Table 5).

Costs

Total costs through all time points were higher in the TSA/RTSA cohort: day of surgery ($27,749 vs $22,959, $P < .0001$), through 90-days ($29,152 vs $24,926, $P < .001$), 1-year ($34,432 vs $29,377, $P < .001$), 2-years ($39,085 vs $34,422, $P < .0001$), and 5-years ($43,742 vs $40,138, $P = .0016$) (Table 4).

Discussion

The present study demonstrates that patients undergoing TSA/RTSA for GH arthritis have higher preoperative co-morbidities but no difference in complication rates with a lower risk of revision surgery at both 2-year and 5-year follow-up when compared to HA. In addition, several risk factors for revision surgery following HA, TSA, and RTSA were identified including increasing age, female sex, hyperlipidemia, postoperative infection, instability, and thromboembolism. We also found that higher costs are associated with TSA/RTSA than with HA. Finally, it was noted that there was no difference in the number of early postoperative complications and revisions for younger patients (less than or equal to 50 years of age) who underwent HA when compared to patients who underwent TSA/RTSA for GH arthritis.

The revision rates reported in this study for HA at 2-year and 5-year follow-up were found to be 3.0% and 3.7%, respectively and for TSA/RTSA were found to be 1.6% and 1.9%. These revision rates are somewhat lower than what has been previously reported in the literature. Kiet et al[12] found that revision rates at 2 years following RTSA to be around 9% and around 11% following TSA. Schwartz et al[13] reported a similar revision burden in TSA of 10.4% based on National Center for Health Statistics National Hospital Discharge Survey (NHDS) data. Furthermore, they found no difference in revision rates

Table 6. Postoperative Complications in Younger Patients (≤ 50 years)—Within 90 days.

Variables (%)	Hemiarthroplasty (n = 416)	TSA (n = 769)	*P* value
Any complication	85 (20.4)	160 (20.8)	.8795
Stiffness	56 (13.5)	116 (15.1)	.4491
Shoulder instability	20 (4.8)	24 (3.1)	.1427
Infection	10 (2.4)	17 (2.2)	.8315
Nerve injury	0 (0.0)	4 (0.5)	.1406
Wound complication	1 (0.2)	3 (0.4)	.6714
VTE	3 (0.7)	4 (0.5)	.6665

Abbreviations: HA, hemiarthroplasty; TSA, total shoulder arthroplasty; RTSA, reverse total shoulder arthroplasty. Bolded values identify statistical significance.

Table 7. Quality Outcomes in Younger Patients (≤ 50 years).

Variables (%)	Hemiarthroplasty (n = 416)	TSA (n = 769)	*P* value
Revision surgery			
90-days	2 (0.5)	0 (0.0)	.0543
180 days	6 (1.4)	5 (0.7)	.17478
1 year	12 (2.9)	20 (2.6)	.7736
2 year	28 (6.7)	33 (4.3)	.0697
5 year	33 (7.9)	42 (5.5)	.0954

Abbreviations: HA, hemiarthroplasty; TSA, total shoulder arthroplasty; RTSA, reverse total shoulder arthroplasty. Bolded values identify statistical significance.

between TSA and RTSA. In contrast to what was reported here, a German database study by Hollatz and Stang[14] noted a higher revision rate for TSA than HA (15% vs. 4.7%). A more recent study by Dillon et al[15] reported a revision rate 4.1% for TSA, a rate more similar to what was found in this study. In another database study, Dillon et al[16] found an all-cause revision rate of between 5.3% and 7.8% for a HA, humeral head resurfacing, RTSA, and TSA. In a long-term outcome study of RTSA Bacle et al[17] noted that 12% of patients had undergone revision at an average follow-up of 150 months with an overall implant survival rate of 93% at 10 years. Additionally, in a 20-year registry review at 2 hospitals of patients undergoing primary shoulder arthroplasty with average follow-up of 8.7 years, Gauci et al[18] noted revision rates of 12.7% for HAs, 6.7% for TSAs, and 3.9% for RTSAs. The revision rates identified in our study contribute to the growing body of evidence against HA, even in younger patients without joint disease Tables 6 and 7.

This study found complications rates to be 19.3% for HA and 17.6% for TSA/RTSA with no statistical difference between the 2. Magosch et al[19] found a higher rate of rotator cuff deficiency after TSA (25%) when compared to HA at long-term follow-up following stemless humeral head implantation, which they believe was the cause of higher revision rates in this group. Kiet et al[12] found the rate of major complications following TSA and RTSA to be 15% and 13%, respectively, at 2-year follow-up, with the most common complications as fracture for RTSA and rotator cuff tear for TSA, which is similar to our reported complication rates. Bacle et al[17] noted a complication rate of 29% at mean 150-month follow-up, and other long-term follow-up series have demonstrated a complication rate follow RTSA of between 15% and 21%, again consistent with our results.[20–23] In a study comparing RTSA to HA for proximal humerus fracture, no difference was noted in local complication rate between the 2.[24]

This study identified several factors that confer an increased risk of revision surgery in HA, TSA, and RTSA including increasing age, female sex, hyperlipidemia, postoperative infection, instability, and thromboembolism. Additionally, it is important to note that operative, including history of rotator cuff repair, did not influence revision rates. In contrast to this study, Hollatz et al[14] noted a 3-fold higher relative revision burden for TSA than for HA.[14] Furthermore, they noted that increased CCI was associated with a higher relative burden of revision. In a Norwegian study of 1 531 HA, 69 TSA, and 225 RTSA, risk factors for revision following HA were younger patients that those patients 70 years or older having half the risk of revision which is in contrast to our study and those that had HA for fracture.[25] In addition, instability was a less common cause of revision, with the most common reason cited in this study as pain.[25] Another study by Singh et al[26] looked at 1 431 humeral head replacements over a 30-year period and found in multivariate-adjusted analyses, male gender, younger age, higher body mass index (BMI), and higher ASA class were all associated with higher risk of revision. Higher BMI and hyperlipidemia likely correlate which is consistent with findings in our study, however, Singh et al pointed to a higher revision rate in younger patients and men for HA. In a similar study looking at TSA over a 30-year time period, Singh et al[27] found male gender and rotator cuff disease to be independent risk factors for revision in TSA. Finally, in a study of 1904 patients who underwent RTSA Lehtimäki et al[28] found that the most common reason for revision was infection, followed by loosening and instability, and that most of these revisions occurred in less than 6 months after the primary operation. Additionally, they noted that men had a significantly increased risk of revision compared with women.

No difference in the number of revisions or early postoperative complications was noted in younger patients (<50 years old) who underwent HA when compared to TSA/RTSA. Due to the age of this subgroup analysis, one can assume that many of these patients underwent TSA as opposed to RTSA.[29] Because of this, the present study represents a reasonable comparison of HA to TSA in patients with GH arthritis. The results of this study are in contrast however in contrast to what has been reported in the literature when comparing TSA and HA revision rates. Bartelt et al[30] determined a projected implant survival rate for TSA at 10 years to be 92% when compared to only 72% for HA in those patients aged 55 years or younger. Levine et al[31] also noted that at long-term follow-up (average 17.2 years), only 25% of patients with GH arthritis treated with HA were satisfied with their results, and patients who had secondary arthritis and eccentric glenoid wear had worse outcomes. In another study, Wirth et al[32] looked at a series of 43 patients with an average age of 63 years old treated with HA for GH arthritis. These patients were followed for a minimum of 5 years, and they found that patients had improved range of motion and outcome scores both of which were maintained at final follow-up, while only 1 patient required a revision. In their study, patients were strictly selected and those that were included needed a concentric glenoid (or one that could be made so via reaming), and the humeral head was centered on the glenoid (or could be centered intraoperatively). These results highlight the importance of patient selection when considering a patient for HA. The conflicting results of this present study could arise from the data source, as a large database study may not exercise the same caution with patient selection as other studies.

As with all large database studies, interpretations of this study are limited by the retrospective and administrative nature of the data. Compared to other more frequently used databases in the orthopedic literature such as PearlDiver (PearlDiver Technologies Inc), Marketscan's larger cohort of unique patients (approximately 3 times more than PearlDiver) and significantly lower rates of loss to follow-up make it a particularly rich source of data.

However, because patients, procedures, and clinical outcomes were queried using ICD-9-CM and CPT codes, it is not possible to assess the underlying validity of the collected records and the analysis is limited by the accuracy and completeness of the code. Furthermore, we were unable to determine based on code whether patients underwent TSA or RTSA and as a result these results were grouped together for comparison to HA. Using a large dataset such as MarketScan provides for powerful analyses but lacks clinical details, specifically shoulder functional status, radiographic findings, detailed physical examinations, clinical outcomes, cause for revision, and more detailed long-term follow up. Finally, patients frequently switch health plans, so it is possible that our longer-term costs and complication data are less robust versus early follow-up data.

Conclusion

Patients undergoing TSA or RTSA for GH arthritis had higher preoperative co-morbidities but had no difference in complication rates with a lower risk of revision surgery at both 2-year and 5-year follow-up when compared to HA. However, younger patients who underwent HA or TSA/RTSA had no difference in revisions. Additionally, the costs associated with TSA/RTSA were higher when compared to HA in this data set. Finally, increasing age, female sex, hyperlipidemia, postoperative infection, shoulder instability, and thromboembolism all independently increased odds for revision shoulder arthroplasty for GH arthritis.

ORCID iD

Julia Ralph https://orcid.org/0009-0001-7703-9400

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