applied sciences

MDPI

Review

Anatomic Total Shoulder Arthroplasty versus Hemiarthroplasty for Glenohumeral Osteoarthritis: A Systematic Review and Meta-Analysis

Filippo Migliorini [1,*], Gianluca Vecchio [2], Alice Baroncini [1], Andrea Pintore [2], Francesco Oliva [2] and Nicola Maffulli [2,3,4]

1 Department of Orthopaedic, Trauma, and Reconstructive Surgery, RWTH University Hospital, 52074 Aachen, Germany; alice.baroncini@artemed.de
2 Department of Medicine, Surgery and Dentistry, University of Salerno, 84081 Baronissi, Italy; g.vecchio129@outlook.com (G.V.); apintore@unisa.it (A.P.); olivafrancesco@hotmail.com (F.O.); n.maffulli@qmul.ac.uk (N.M.)
3 School of Pharmacy and Bioengineering, Faculty of Medicine, Keele University, Stoke-on-Trent ST4 7QB, UK
4 Mile End Hospital, Centre for Sports and Exercise Medicine, Barts and The London School of Medicine and Dentistry, Queen Mary University of London, London E1 4DG, UK
* Correspondence: migliorini.md@gmail.com; Tel.: +49-0241-80-35529

Abstract: Purpose: Both anatomic total shoulder arthroplasty (TSA) and shoulder hemiarthroplasty (SHA) are used for the management of end-stage glenohumeral osteoarthritis (GHOA). The present study compared TSA and SHA in terms of clinical outcome and complication rate. **Methods:** This meta-analysis followed the PRISMA guidelines. In October 2021, the following databases were accessed: Web of Science, Google Scholar, Pubmed, Scopus. All clinical trials comparing anatomical TSA versus SHA for GHOA were considered. **Results:** Data from 11,027 procedures were retrieved. The mean length of the follow-up was 81.8 (16 to 223.20) months. The mean age of the patients was 61.4 ± 8.6 years, and 56.0% (5731 of 10,228 patients) were women. At last follow-up, the age-adjusted constant score was greater following TSA ($p < 0.0001$), as were active elevation ($p < 0.0001$), flexion ($p < 0.0001$), abduction ($p < 0.0001$), and American Shoulder and Elbow Surgeons Shoulder Score ($p < 0.0001$). Postoperative pain ($p < 0.0001$) and revision rate ($p = 0.02$) were lower in the TSA group. **Conclusions:** Anatomic TSA performed better than SHA in patients with GHOA.

Keywords: shoulder; arthroplasty; hemiarthroplasty; glenohumeral osteoarthritis

Citation: Migliorini, F.; Vecchio, G.; Baroncini, A.; Pintore, A.; Oliva, F.; Maffulli, N. Anatomic Total Shoulder Arthroplasty versus Hemiarthroplasty for Glenohumeral Osteoarthritis: A Systematic Review and Meta-Analysis. *Appl. Sci.* **2021**, *11*, 10112. https://doi.org/10.3390/app112110112

Academic Editor: Gaetano Isola

Received: 30 August 2021
Accepted: 24 October 2021
Published: 28 October 2021

1. Introduction

Glenohumeral osteoarthritis (GHOA) is a degenerative disease characterized by the progressive consumption of the articular cartilage of the shoulder [1,2], leading to gradual loss of function and persistent pain [3]. The incidence of GHOA increases exponentially after the age of 50, with greater prevalence in women [1,2]. In the United States, the Nationwide Inpatient Sample database recorded an increasing incidence of shoulder arthroplasty from 2002 to 2011 of 267% [4]. In the elderly population, the demand is expected to increase by up to 755% by 2050 [4]. In the Korean population over 65 years of age, a radiological prevalence of GHOA of 16.1% was found [5]. Especially in young and active adults, nonoperative management should be attempted before considering surgery [6]. When conservative management fails, shoulder replacement may be required [7]. Both anatomic total shoulder arthroplasty (TSA) and shoulder hemiarthroplasty (SHA) are routinely used in patients with GHOA [8–11]. However, it is still controversial which type of implant provides better outcomes [12–22]. Previous systematic reviews and meta-analyses reported better outcomes for TSA [23–26]. However, several recent clinical trials, which were not considered in these meta-analyses, have been published and an update of current evidence is necessary [27–32]. Therefore, the present meta-analysis aimed to compare TSA and SHA through the examination of patient reported outcome measures (PROMs), range of motion (ROM), and the rate of revision between the two implants. A multivariate analysis was also conducted to investigate whether the patient characteristics at baseline influenced the surgical outcome.

2. Materials and Methods

2.1. Search Strategy

This systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses: the PRISMA guidelines [33]. The PICOT algorithm was first considered:

- P (Population): GHOA;
- I (Intervention): TSA;
- C (Comparison): SHA;
- O (Outcomes): PROMs, ROM, and revision rate;
- T (Timing): ≥12 months.

2.2. Data Source and Extraction

Two authors independently (G.V. and A.P.) performed the literature search in October 2021. PubMed and Google scholar were accessed. Afterwards, Web of Science and Scopus were also accessed to identify further articles. The following keywords were used in combination: *shoulder, arthroplasty, hemiarthroplasty, total, glenohumeral, osteoarthritis, prosthesis, implant, clinical, functional, outcomes, humeral, head, replacement, surgery, constant, score, index, complication, revision, pain* (Table 1).

Table 1. Search strategy for the electronic databases.

Database	Terms	Results
PubMed:		
#1	Shoulder	92,763
#2	Arthroplasty	104,761
#3	Hemiarthroplasty	3900
#4	Anatomic	310,373
#5	Glenohumeral	7203
#6	Osteoarthritis	99,581
#7	Prosthesis	600,963
#8	Implant	550,839
#9	Clinical	6,068,222
#10	Functional	14,565,742
#11	Outcomes	2,786,291
#12	Humeral head replacement	880
#13	Surgery	5,125,722
#14	Constant score	10,306
#15	Index	1,221,380
#16	Complication	3,528,187
#17	Revision	180,279
#18	Pain	908,693
Google Scholar:		
#1	Shoulder	4,530,000
#2	Arthroplasty	723,000
#3	Hemiarthroplasty	32,000
#4	Anatomic	1,470,000
#5	Glenohumeral	69,700
#6	Osteoarthritis	1,160,000
#7	Prosthesis	1,040,000
#8	Implant	2,420,000

Table 1. *Cont.*

Database	Terms	Results
#9	Clinical	7,190,000
#10	Functional	5,940,000
#11	Outcomes	5,590,000
#12	Humeral head replacement	43,300
#13	Surgery	4,470,000
#14	Constant score	3,460,000
#15	Index	7,550,000
#16	Complication	3,730,000
#17	Revision	5,630,000
#18	Pain	4,090,000
Web of Science		
#1	Shoulder	83,487
#2	Arthroplasty	94,284
#3	Hemiarthroplasty	3510
#4	Anatomic	279,336
#5	Glenohumeral	6483
#6	Osteoarthritis	89,623
#7	Prosthesis	540,867
#8	Implant	495,755
#9	Clinical	5,461,400
#10	Functional	13,109,168
#11	Outcomes	2,507,662
#12	Humeral head replacement	792
#13	Surgery	4,023,000
#14	Constant score	9275
#15	Index	1,099,242
#16	Complication	3,175,368
#17	Revision	162,251
#18	Pain	817,824
Scopus:		
#1	Shoulder	83,786
#2	Arthroplasty	99,949
#3	Hemiarthroplasty	3180
#4	Anatomic	33,404
#5	Glenohumeral	2155
#6	Osteoarthritis	119,188
#7	Prosthesis	368,331
#8	Implant	226,632
#9	Clinical	7,572,108
#10	Functional	814,309
#11	Outcomes	2,252,255
#12	Humeral head replacement	369
#13	Surgery	1,601,616
#14	Constant score	1430
#15	Index	1,041,256
#16	Complication	1,343,068
#17	Revision	18,592
#18	Pain	909,311

The same two authors separately screened the resulting titles from the above searches. If the title and abstract matched the topic, the full text of the article was accessed. A cross-reference of the bibliographies of the full text was also performed. Disagreements were resolved by a third author (N.M.).

2.3. Eligibility Criteria

All the published studies comparing the outcomes of anatomic TSA and/or SHA for GHOA were accessed. Given the authors' language capabilities, articles in English, German, Italian, French, and Spanish were eligible. Levels I to IV of evidence, according to Oxford Centre of Evidence-Based Medicine [34], were considered. Editorials, reviews technical notes, expert opinion, comments, and letters were excluded. Only anatomic TSA implants were considered. Only studies that involved patients with advanced GHOA associated with severe pain and functional impairment were included. Only studies that reported a minimum of 12 months follow-up were eligible. Only articles reporting quantitative data under the outcomes of interest were considered for inclusion.

2.4. Outcomes of Interest

Data extraction was performed by two authors (G.V. and A.P.). The following data were collected: author, year, journal, type of study, number of prostheses, mean age, mean length of the follow-up, type of implant. The following data were collected at baseline and at last follow-up for each implant (TSA and SHA): Constant score [35], flexion, abduction, ASES questionnaire [36], VAS, ROM. Rates of revision were also retrieved. The primary outcome of interest was to compare the outcomes between TSA and HSA. The second outcome of interest was to perform a multivariate analysis to investigate whether the patient characteristics at baseline had an influence on the clinical outcome.

2.5. Methodology Quality Assessment

Two authors (G.V. and A.P.) independently performed the methodological quality assessment using the Coleman Methodology Score (CMS) [37]. The CMS is a validated tool to assess the quality of the methodology in systematic reviews and meta-analyses. The CMS is based on several endpoints: study size, length of the follow-up, surgical approach, type of study, description of diagnosis, surgical technique, and rehabilitation. Additionally, outcome criteria assessment, procedures for assessing outcomes, and the recruitment process were also evaluated. The CMS rates articles with values between 0 (poor) and 100 (excellent). Articles with values >60 are considered satisfactory.

2.6. Statistical Analysis

The statistical analyses were performed by the main author (F.M.). The meta-analyses were performed using Editorial Manager Software version 5.3 (The Nordic Cochrane Collaboration, Copenhagen, Denmark). Dichotomic data were analyzed through the Mantel-Haenszel method and the odds ratio (OR) effect measure. Continuous data were analyzed using the inverse variance method, with the mean difference (MD) effect measure. The confidence interval was set at 95% for all comparisons. Heterogeneity was evaluated through Higgins-I^2 and χ^2 tests. If $\chi^2 < 0.05$, statistically significant heterogeneity was detected. Values of Higgins-I^2 were interpreted as low (<30%), moderate (30% to 60%), or high (>60%). A fixed-effects model was set as default. If moderate or high heterogeneity was detected, a random-effects model was adopted. For the multivariate analyses, STATA software (StataCorp, College Station, TX, USA) was used. Multiple pairwise correlations according to the Pearson Product-Moment Correlation Coefficient (r) were conducted. According to the Cauchy–Schwarz inequality, the final effect was ranked between +1 (positive linear correlation) and −1 (negative linear correlation). Values of $0.1 < |r| < 0.3$, $0.3 < |r| < 0.5$, and $|r| > 0.5$ were considered to have poor, moderate, and strong correlation, respectively. Overall significance was evaluated using the χ^2 test. Values of $p < 0.05$ were considered statistically significant.

3. Results

3.1. Search Results

The initial search resulted in 1346 articles. Of them, 423 were excluded as they were duplicates. Another 874 studies were excluded as they did not match the eligibility criteria: study design (N = 349), not matching the topic (N = 385), language limitations (N = 4), use of experimental rehabilitation (N = 5), short duration of the follow-up (N = 31), revision setting (N = 56), unclear source of data or criteria (N = 44). An additional 15 studies were excluded because of the lack of reporting of quantitative data related to the outcomes of interests. This left 34 studies for analysis. A schematic of the number of literature search results is shown in Figure 1.

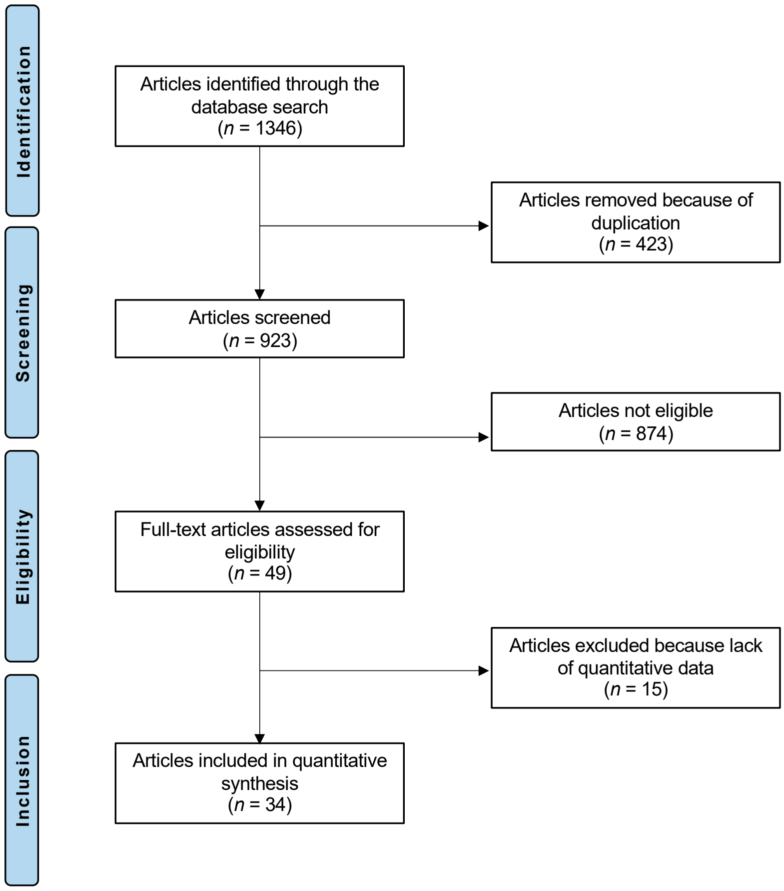

Figure 1. Flow chart of the number of literature search results.

3.2. Risk of Publication Bias

The funnel plot of the most commonly reported outcome (revision) was performed to assess the risk of publication bias (Figure 2). The referral points demonstrated symmetrical distribution, mostly within the pyramidal shapes, indicating a low risk of publication bias.

3.3. Methodological Quality Assessment

The study size and the length of the follow-up were acceptable in most studies. Surgical approach and rehabilitation were well described, and the outcome measures and timing of assessment were often defined, providing moderate reliability. The diagnosis was poorly described. The procedure for assessing outcomes and subject selection was often biased and not satisfactorily described. Overall, the CMS was 70.4 points, attesting an acceptable methodological assessment (Table 2).

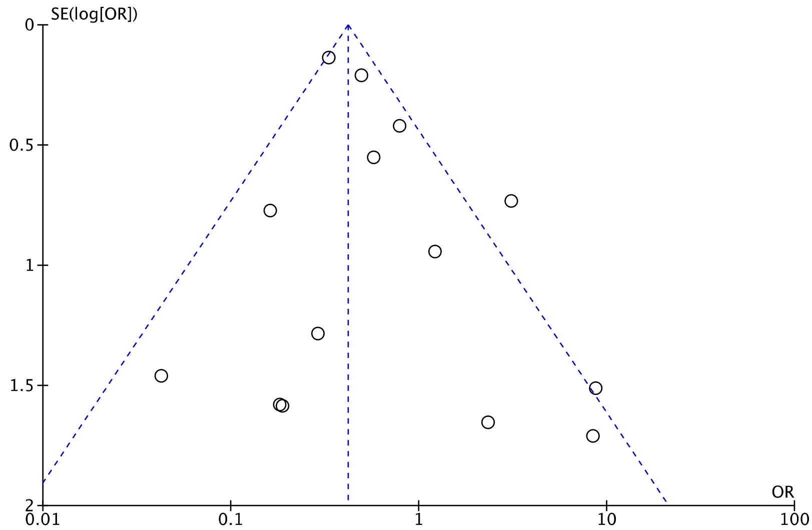

Figure 2. Funnel plot.

Table 2. Methodological quality assessment.

Endpoint	Mean
Part A: Only one score to be given for each of the 7 sections	
Study size: number of patients	4.8
Mean follow-up	6.4
Surgical approach	7.0
Type of study	4.0
Description of diagnosis	2.5
Description of surgical technique	9.0
Description of postoperative rehabilitation	4.5
Part B: Scores may be given for each option in each of the 3 sections	
Outcome criteria	2.0
Procedure of assessing outcomes	3.0
Description of subject selection process	4.0

3.4. Patient Demographics

Data from 11,027 procedures were retrieved. The mean follow-up was 85.4 ± 49.1 months. The mean age of the patients was 61.4 ± 8.6 years of age, and 56.0% (5731 of 10,228) were female. Baseline comparability between the two groups was detected for length of follow-up ($p = 0.3$), active elevation ($p = 0.7$), and abduction ($p = 0.1$). Study generalities and patient baseline values are shown in Table 3.

3.5. Outcomes of Interest

At the last follow-up, the TSA group demonstrated greater improvement in elevation (MD 5.21; 95% CI 2.855 to 7.564; $p < 0.0001$), flexion (MD 5.440; 95% CI 3.164 to 7.715; $p < 0.0001$), abduction (MD 6.110; 95% CI 4.333 to 7.887; $p < 0.0001$), and ASES score (MD 4.960; 95% CI 3.062 to 6.857; $p < 0.0001$). VAS was lower in the TSA group (MD −1.470; 95% CI −1.672 to −1.267, $p < 0.0001$).

Table 3. Generalities and patient baseline of the included studies.

Author, Year	Journal	Type of Study	Type of Surgery	CMS	Procedures (*n*)	Mean Age	Female (%)	Follow-Up (Months)
Al-Hadithy et al., 2012 [38]	*J Shoulder Elb Surg*	Retrospective	SHA	69.0	50	69.0	65	50.0
Bartelt et al., 2011 [39]	*J Shoulder Elb Surg*	Retrospective	TSA SHA	68.0	46 20	49.0 49.0	28 20	72.0 111.6
Bell et al., 1986 [17]	*Int Orthop*	Retrospective	TSA SHA	64.0	11 17	57.0		16.0
Boyd et al., 1990 [19]	*J Arthroplasty*	Retrospective	TSA SHA	72.0	146 64	60.0 58.0	75 66	45.0 43.0
Buchner et al., 2007 [21]	*Arch Orthop Trauma Surg*	Retrospective	TSA SHA	63.0	22 22	61.0 61.0	50 50	
Deshmukh et al., 2005 [40]	*J Shoulder Elb Surg*	Retrospective	TSA	78.0	320	60.3	78	104.4
Edwards et al., 2003 [41]	*J Shoulder Elb Surg*	Retrospective	TSA SHA	72.0	601 89	67.4 66.2		44.0 38.6
Foruria et al., 2010 [42]	*J Bone Jt Surg*	Retrospective	TSA	68.0	50	82.0		66.0
Jost et al., 2011 [43]	*Hss Journal*	Retrospective	TSA	66.0	49	67.0	46	29.0
Khan et al., 2009 [44]	*J Bone Jt Surg*	Prospective	TSA	75.0	12 13	78.6	96	127.2
Krishnan et al., 2007 [45]	*J Bone Jt Surg*	Prospective	SHA	78.0	36	51.0	11	84.0
Levy et al., 2001 [46]	*J Bone Jt Surg*	Retrospective	TSA SHA	72.0	61 37	64.3	22	82.0
Levy et al., 2004 [47]	*J Shoulder Elb Surg*	Retrospective	TSA SHA	72.0	42 37	71.5 73.4		91.0 53.0
Liu et al., 2020 [48]	*Hss Journal*	Retrospective	TSA SHA	69.0	23 26	61.7 62.4	56 53	66.9 67.5
Lo et al., 2005 [27]	*J Bone Jt Surg*	Randomized	TSA SHA	74.0	20 21	70.4 70.3	50 62	24.0 24.0
Magosh et al., 2020 [29]	*J Shoulder Elb Surg*	Prospective	TSA SHA	78.0	35 40	57.0 57.0	37 62	121.9 128.3
Orfaly et al., 2003 [22]	*J Shoulder Elb Surg*	Prospective	TSA SHA	75.0	37 28	63.0	29	52.0
Orfaly et al., 2007 [49]	*J Shoulder Elb Surg*	Prospective	TSA SHA	76.0	6 15	54.0	74	56.0
Pfahler et al., 2006 [50]	*J Shoulder Elb Surg*	Retrospective	TSA SHA	72.0	705 469	63.9	73	43.0
Raiss et al., 2008 [51]	*J Bone Jt Surg*	Prospective	TSA	78.0	21	55.0	43	84.0
Rasmussen et al., 2018 [30]	*Osteoarthr Cartilage*	Prospective	TSA SHA	78.0	2340 3510		58 56	37.2 51.6
Rispoli et al., 2006 [52]	*J Bone Jt Surg*	Retrospective	SHA	71.0	51	59.0	38	135.6
Robinson et al., 2017 [53]	*J Shoulder Elb Surg*	Prospective	SHA	78.0	44	58.0	39	204.0
Sandow et al., 2013 [28]	*J Shoulder Elb Surg*	Randomized	TSA SHA	74.0	20 13			36.0
Schoch et al., 2016 [32]	*J Shoulder Elb Surg*	Retrospective	TSA SHA	72.0	46 37	65.0 55.0	94 73	87.6 130.8
Sowa et al., 2017 [31]	*Acta Orthop*	Prospective	TSA SHA	77.0	282 214	65.0	69	57.0 45.0
Sperling et al., 2004 [54]	*J Shoulder Elb Surg*	Prospective	TSA SHA	78.0	36 78	41.0 39.0	73 47	223.2 183.6
Sperling et al., 2007 [55]	*J Shoulder Elb Surg*	Retrospective	TSA SHA	75.0	187 95	57.0 54.0	71 77	135.6 145.2

Table 3. *Cont.*

Author, Year	Journal	Type of Study	Type of Surgery	CMS	Procedures (*n*)	Mean Age	Female (%)	Follow-Up (Months)
Tammachote et al., 2009 [56]	*J Bone Jt Surg*	Retrospective	TSA	75.0	100	68.0	35	129.6
Taunton et al., 2008 [57]	*J Bone Jt Surg*	Retrospective	TSA	71.0	83	68.0	39	114.0
Torchia et al., 1997 [58]	*J Shoulder Elb Surg*	Retrospective	TSA	75.0	53 18	54.0 59.0	82 71	146.4
Walch et al., 2011 [59]	*J Shoulder Elb Surg*	Retrospective	TSA	74.0	311	69.3	68.5	89.5
Wirth et al., 2006 [60]	*J Bone Jt Surg*	Retrospective	SHA	68.0	50	64.0	42	90.0
Young et al., 2011 [61]	*J Bone Jt Surg*	Retrospective	TSA	74.0	226	66.9	68	124.1

3.6. Meta-Analysis

The Constant score and the rate of revision were included in the meta-analysis.

The Constant score, evaluated in four studies [21,27,29,50], was higher in the TSA group (MD 7.57; 95% CI 0.57, 14.58; $p = 0.03$; Figure 3).

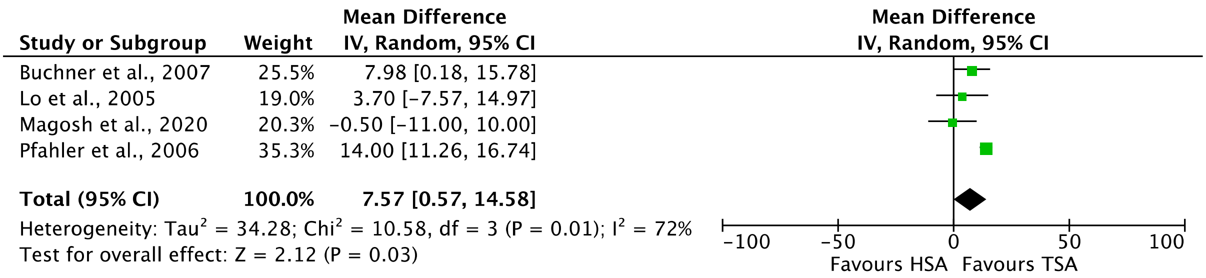

Figure 3. Meta-analysis of the comparison: Age-adjusted Constant score.

Fourteen studies compared the rate of revision surgery [21,22,27–32,39,47,49,50,54,55]; this was lower in the TSA group (OR 0.57; 95% CI 0.35, 0.92; $p = 0.02$; Figure 4).

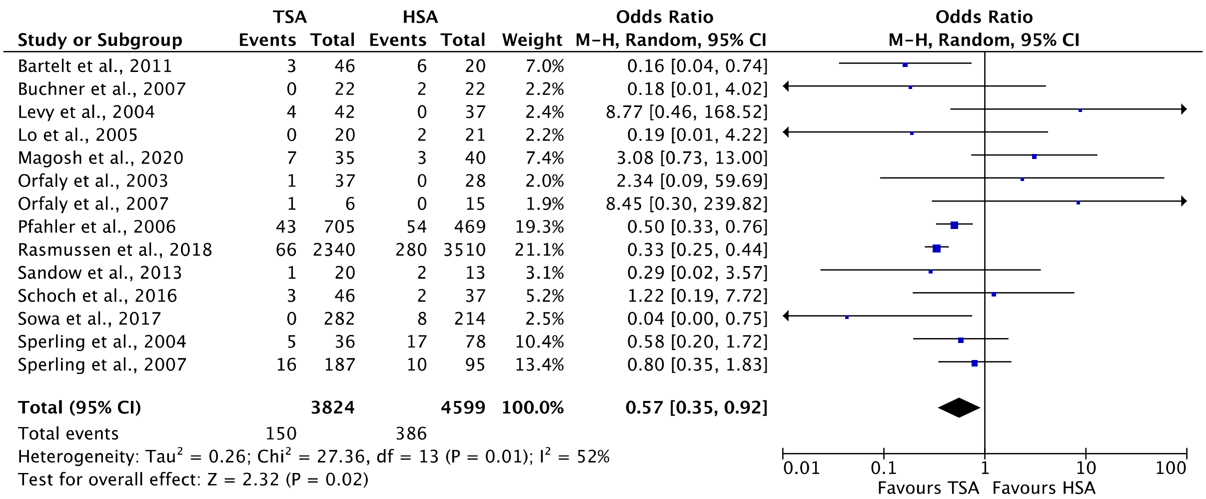

Figure 4. Meta-analysis of the comparison: Revision rate.

3.7. Multivariate Analysis

The age-adjusted Constant score at baseline was strongly associated with the same score at last follow-up ($r = 0.56$; $p = 0.02$). Similar findings were found for elevation ($r = 0.88$; $p = 0.003$), flexion ($r = 0.79$; $p = 0.0003$), and abduction ($r = 0.70$; $p = 0.004$).

4. Discussion

Based on the main findings of this study, anatomic TSA performed better than SHA for GHOA. At last follow-up, the TSA group demonstrated greater flexion, abduction, and elevation. ASES and VAS were both greater in the TSA group. TSA demonstrated a higher age-adjusted Constant score and a lower rate of revision surgery. The results of the multivariate analysis suggested that the surgical outcome was strongly influenced by the preoperative performance status.

A previous systematic review, which analyzed 1952 patients, showed that TSA was effective in reducing pain and improving ROM and patient satisfaction. The same study evidenced that TSA resulted in a significantly lower rate of revision surgery (6.5% versus 10.2%) [23]. A more recent review involving 2111 procedures (1783 TSA and 328 SHA) also found a lower revision rate in TSA (7% versus 13%) [24]. A previous meta-analysis involving 62 TSA procedures revealed a higher University of California at Los Angeles

(UCLA) Shoulder Score than SHA [25]. Similarly, in a more recent meta-analysis including 153 procedures, TSA provides better clinical results than SHA [26]. Indeed, higher UCLA Shoulder Score and ASES were found in the TSA group [26]. In contrast, there was no significant difference between TSA and HA in revision, Western Ontario Osteoarthritis of the Shoulder (WOOS) index, and instability [26]. The present systematic review and meta-analysis confirmed similar findings on a larger scale, analyzing more procedures and outcomes of interest compared with previous studies.

Pain relief and full functional recovery are the primary goals of shoulder prostheses [62]. TSA aims to restore the physiological biomechanics of the shoulder joint: spherical size, orientation, center of rotation, capsular tension, joint stability, and range of motion [63]. Neck inclination, humeral head diameter, thickness, height, retroversion, offset, and acromion–humeral distance are the main parameters to follow for a successful implant [64–66]. Polyethylene wear, aseptic loosening, and the erosion of the glenoid component are the most common complication of TSA [24,67–70]. SHA is easier to perform and requires shorter surgical duration and learning curve [71]. HA is advantageous in the early stages of OA with eccentric GHOA [50]; however, given the higher risk of glenoid bone erosion, its use in advanced GHOA is controversial [72]. TSA, in contrast, is more demanding, with greater tissue damage, blood loss, and recovery time [73], but humeral component loosening is uncommon [74,75]. However, TSA provides greater joint stability, less pain, and increased ROM, especially in internal rotation [76,77], as highlighted by long-term follow-up studies [22,78]. In addition, TSA showed a lower rate of revision surgery, and is more cost effective than SHA [30,79,80]. Indeed, although TSA has higher initial costs, primarily from the longer operative time and the expense of the glenoid component [81], the lower revision rate of surgery and higher health-related quality-of-life (calculated by quality-adjusted life years, QALYs) make TSA more effective and less costly than the alternative [79]. Glenoid component failure is the most common complication leading to revision surgery following TSA [68,82,83], and may discourage the use of glenoid components in younger patients desiring higher activity levels [68,82,84–86].

The present study has several limitations. The retrospective design of most of the included studies has a negative effect on the reliability of the conclusions. Given the limited quantitative data available in the current literature, surgical techniques, approaches, and implants were not analyzed separately. Between-study heterogeneity in the eligibility criteria was shown. The included studies reported that patients presenting severe pain unresponsive to nonoperative management and associated with functional limitation and radiographic signs of GHOA were eligible for replacement. Patients with secondary GHOA, such as history of trauma, instability, rheumatoid arthritis, avascular necrosis of the humeral head, and prior shoulder surgery were not eligible in most of the studies [21,27,30,38,41,48,56,57,61]. Some authors required a period of persistent pain [19,31,39,43,44,48,52,53,55], others required 3 to 6 months of nonoperative managements, including analgesics, anti-inflammatory medications, physiotherapy, and home range-of-motion exercise programs [27,31,45,49]. Two studies performed the intervention in patients younger than 50 years of age [39,54]. However, many studies did not report any inclusion or exclusion criteria [17,22,29,40,42,46,47,50,58–60]. The status of the rotator cuff influences the outcome of shoulder replacement [82]. In rotator cuff-deficient patients, the unopposed action of the deltoid causes superior migration of the humeral head toward the acromion and coracoacromial arch, leading to poor functional results, glenoid component loosening, and reduced implant survivorship [87]. The average arm forward elevation of patients with impaired rotator cuff was 88°, whereas 150° was achieved by patients with intact rotator cuff [88]. The status of the rotator cuff in patients included in the studies considered for the present investigation was homogeneous and often biased, thus representing a further limitation. In some of the studies included in our article, the rotator cuff was intact before surgery [21,22,27,28,30,32,38,41,48,49,51,56,57,61]. Other authors repaired intraoperatively rotator cuff lesions [17,19,29,31,39,40,42,44,46,47,50,52–55,58–60]. Two studies did not specify the status of the rotator cuff in their patients [43,45]. The age-adjusted Constant score has been used for analysis; however, although widely used to assess outcome for shoulder implants, the score itself is not validated [35]. Given these limitations, the data from the present study must be interpreted with caution.

5. Conclusions

Anatomic TSA performed better than SHA in patients with glenohumeral osteoarthritis.

Author Contributions: F.M.: writing, data items, statistical analyses; G.V.: data source and extraction, selection and data collection, data items, methodology quality assessment; A.B.: writing; A.P.: writing, data source and extraction, selection and data collection, data items, methodology quality assessment; F.O.: supervision; N.M.: supervision. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data is contained within article.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Macias-Hernandez, S.I.; Morones-Alba, J.D.; Miranda-Duarte, A.; Coronado-Zarco, R.; Soria-Bastida, M.L.A.; Nava-Bringas, T.; Cruz-Medina, E.; Olascoaga-Gomez, A.; Tallabs-Almazan, L.V.; Palencia, C. Glenohumeral osteoarthritis: Overview, therapy, and rehabilitation. *Disabil. Rehabil.* **2017**, *39*, 1674–1682. [CrossRef]
2. Millett, P.J.; Gobezie, R.; Boykin, R.E. Shoulder osteoarthritis: Diagnosis and management. *Am. Fam. Physician* **2008**, *78*, 605–611. [PubMed]
3. Walch, G.; Badet, R.; Boulahia, A.; Khoury, A. Morphologic study of the glenoid in primary glenohumeral osteoarthritis. *J. Arthroplast.* **1999**, *14*, 756–760. [CrossRef]
4. Padegimas, E.M.; Maltenfort, M.; Lazarus, M.D.; Ramsey, M.L.; Williams, G.R.; Namdari, S. Future patient demand for shoulder arthroplasty by younger patients: National projections. *Clin. Orthop. Relat. Res.* **2015**, *473*, 1860–1867. [CrossRef]
5. Oh, J.H.; Chung, S.W.; Oh, C.H.; Kim, S.H.; Park, S.J.; Kim, K.W.; Park, J.H.; Lee, S.B.; Lee, J.J. The prevalence of shoulder osteoarthritis in the elderly Korean population: Association with risk factors and function. *J. Shoulder Elb. Surg.* **2011**, *20*, 756–763. [CrossRef]
6. Takamura, K.M.; Chen, J.B.; Petrigliano, F.A. Nonarthroplasty Options for the Athlete or Active Individual with Shoulder Osteoarthritis. *Clin. Sports Med.* **2018**, *37*, 517–526. [CrossRef]
7. Ansok, C.B.; Muh, S.J. Optimal management of glenohumeral osteoarthritis. *Orthop. Res. Rev.* **2018**, *10*, 9–18. [CrossRef]
8. Sperling, J.W.; Cofield, R.H. Revision total shoulder arthroplasty for the treatment of glenoid arthrosis. *J. Bone Jt. Surg. Am.* **1998**, *80*, 860–867. [CrossRef]
9. Sperling, J.W.; Cofield, R.H.; Rowland, C.M. Neer hemiarthroplasty and Neer total shoulder arthroplasty in patients fifty years old or less. Long-term results. *J. Bone Jt. Surg. Am.* **1998**, *80*, 464–473. [CrossRef] [PubMed]
10. Petersen, S.A.; Hawkins, R.J. Revision of failed total shoulder arthroplasty. *Orthop. Clin. N. Am.* **1998**, *29*, 519–533. [CrossRef]
11. Wirth, M.A.; Rockwood, C.A., Jr. Complications of total shoulder-replacement arthroplasty. *J. Bone Jt. Surg. Am.* **1996**, *78*, 603–616. [CrossRef] [PubMed]
12. Amstutz, H.C.; Sew Hoy, A.L.; Clarke, I.C. UCLA anatomic total shoulder arthroplasty. *Clin. Orthop. Relat. Res.* **1981**, *155*, 7–20. [CrossRef]
13. Barrett, W.P.; Franklin, J.L.; Jackins, S.E.; Wyss, C.R.; Matsen, F.A., 3rd. Total shoulder arthroplasty. *J. Bone Jt. Surg. Am.* **1987**, *69*, 865–872. [CrossRef]
14. Cofield, R.H. Total shoulder arthroplasty with the Neer prosthesis. *J. Bone Jt. Surg. Am.* **1984**, *66*, 899–906. [CrossRef]
15. Cofield, R.H.; Frankle, M.A.; Zuckerman, J.D. Humeral head replacement for glenohumeral arthritis. *Semin. Arthroplast.* **1995**, *6*, 214–221.
16. Fenlin, J.M., Jr.; Ramsey, M.L.; Allardyce, T.J.; Frieman, B.G. Modular total shoulder replacement. Design rationale, indications, and results. *Clin. Orthop. Relat. Res.* **1994**, *307*, 37–46.
17. Bell, S.N.; Gschwend, N. Clinical experience with total arthroplasty and hemiarthroplasty of the shoulder using the Neer prosthesis. *Int. Orthop.* **1986**, *10*, 217–222. [CrossRef] [PubMed]
18. Bonutti, P.M.; Hawkins, R.J.; Saddemi, S. Arthroscopic assessment of glenoid component loosening after total shoulder arthroplasty. *Arthroscopy* **1993**, *9*, 272–276. [CrossRef]
19. Boyd, A.D., Jr.; Thomas, W.H.; Scott, R.D.; Sledge, C.B.; Thornhill, T.S. Total shoulder arthroplasty versus hemiarthroplasty. Indications for glenoid resurfacing. *J. Arthroplasty* **1990**, *5*, 329–336. [CrossRef]

20. Brostrom, L.A.; Kronberg, M.; Wallensten, R. Should the glenoid be replaced in shoulder arthroplasty with an unconstrained Dana or St. Georg prosthesis? *Ann. Chir. Gynaecol.* **1992**, *81*, 54–57.
21. Buchner, M.; Eschbach, N.; Loew, M. Comparison of the short-term functional results after surface replacement and total shoulder arthroplasty for osteoarthritis of the shoulder: A matched-pair analysis. *Arch. Orthop. Trauma Surg.* **2008**, *128*, 347–354. [CrossRef] [PubMed]
22. Orfaly, R.M.; Rockwood, C.A., Jr.; Esenyel, C.Z.; Wirth, M.A. A prospective functional outcome study of shoulder arthroplasty for osteoarthritis with an intact rotator cuff. *J. Shoulder Elb. Surg.* **2003**, *12*, 214–221. [CrossRef]
23. Radnay, C.S.; Setter, K.J.; Chambers, L.; Levine, W.N.; Bigliani, L.U.; Ahmad, C.S. Total shoulder replacement compared with humeral head replacement for the treatment of primary glenohumeral osteoarthritis: A systematic review. *J. Shoulder Elb. Surg.* **2007**, *16*, 396–402. [CrossRef]
24. van den Bekerom, M.P.; Geervliet, P.C.; Somford, M.P.; van den Borne, M.P.; Boer, R. Total shoulder arthroplasty versus hemiarthroplasty for glenohumeral arthritis: A systematic review of the literature at long-term follow-up. *Int. J. Shoulder Surg.* **2013**, *7*, 110–115. [CrossRef] [PubMed]
25. Bryant, D.; Litchfield, R.; Sandow, M.; Gartsman, G.M.; Guyatt, G.; Kirkley, A. A comparison of pain, strength, range of motion, and functional outcomes after hemiarthroplasty and total shoulder arthroplasty in patients with osteoarthritis of the shoulder. A systematic review and meta-analysis. *J. Bone Jt. Surg. Am.* **2005**, *87*, 1947–1956. [CrossRef]
26. Duan, X.; Zhang, W.; Dong, X.; Liu, M.; Gao, Y.; Huang, F.; Li, J.; Xiang, Z. Total shoulder arthroplasty versus hemiarthroplasty in patients with shoulder osteoarthritis: A meta-analysis of randomized controlled trials. *Semin. Arthritis Rheum.* **2013**, *43*, 297–302. [CrossRef] [PubMed]
27. Lo, I.K.; Litchfield, R.B.; Griffin, S.; Faber, K.; Patterson, S.D.; Kirkley, A. Quality-of-life outcome following hemiarthroplasty or total shoulder arthroplasty in patients with osteoarthritis. A prospective, randomized trial. *J. Bone Jt. Surg. Am.* **2005**, *87*, 2178–2185. [CrossRef]
28. Sandow, M.J.; David, H.; Bentall, S.J. Hemiarthroplasty vs total shoulder replacement for rotator cuff intact osteoarthritis: How do they fare after a decade? *J. Shoulder Elb. Surg.* **2013**, *22*, 877–885. [CrossRef] [PubMed]
29. Magosch, P.; Lichtenberg, S.; Habermeyer, P. Survival of stemless humeral head replacement in anatomic shoulder arthroplasty: A prospective study. *J. Shoulder Elb. Surg.* **2020**, *30*, e343–e355. [CrossRef]
30. Rasmussen, J.V.; Hole, R.; Metlie, T.; Brorson, S.; Aarimaa, V.; Demir, Y.; Salomonsson, B.; Jensen, S.L. Anatomical total shoulder arthroplasty used for glenohumeral osteoarthritis has higher survival rates than hemiarthroplasty: A Nordic registry-based study. *Osteoarthr. Cartil.* **2018**, *26*, 659–665. [CrossRef]
31. Sowa, B.; Thierjung, H.; Bulhoff, M.; Loew, M.; Zeifang, F.; Bruckner, T.; Raiss, P. Functional results of hemi- and total shoulder arthroplasty according to diagnosis and patient age at surgery. *Acta Orthop.* **2017**, *88*, 310–314. [CrossRef]
32. Schoch, B.S.; Barlow, J.D.; Schleck, C.; Cofield, R.H.; Sperling, J.W. Shoulder arthroplasty for post-traumatic osteonecrosis of the humeral head. *J. Shoulder Elb. Surg.* **2016**, *25*, 406–412. [CrossRef]
33. Moher, D.; Liberati, A.; Tetzlaff, J.; Altman, D.G.; Group, P. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *BMJ* **2009**, *339*, b2535. [CrossRef]
34. Howick, J.C.I.; Glasziou, P.; Greenhalgh, T.; Liberati, A.C.H.; Moschetti, I.; Phillips, B.; Thornton, H.; Goddard, O.; Hodgkinson, M. The 2011 Oxford CEBM Levels of Evidence. Oxford Centre for Evidence-Based Medicine. 2011. Available online: https://wwwcebmnet/indexaspx?o=5653 (accessed on 18 August 2021).
35. Constant, C.R.; Murley, A.H. A clinical method of functional assessment of the shoulder. *Clin. Orthop. Relat. Res.* **1987**, *214*, 160–164. [CrossRef]
36. Richards, R.R.; An, K.N.; Bigliani, L.U.; Friedman, R.J.; Gartsman, G.M.; Gristina, A.G.; Iannotti, J.P.; Mow, V.C.; Sidles, J.A.; Zuckerman, J.D. A standardized method for the assessment of shoulder function. *J. Shoulder Elb. Surg.* **1994**, *3*, 347–352. [CrossRef]
37. Coleman, B.D.; Khan, K.M.; Maffulli, N.; Cook, J.L.; Wark, J.D. Studies of surgical outcome after patellar tendinopathy: Clinical significance of methodological deficiencies and guidelines for future studies. Victorian Institute of Sport Tendon Study Group. *Scand. J. Med. Sci. Sports* **2000**, *10*, 2–11. [CrossRef]
38. Al-Hadithy, N.; Domos, P.; Sewell, M.D.; Naleem, A.; Papanna, M.C.; Pandit, R. Cementless surface replacement arthroplasty of the shoulder for osteoarthritis: Results of fifty Mark III Copeland prosthesis from an independent center with four-year mean follow-up. *J. Shoulder Elb. Surg.* **2012**, *21*, 1776–1781. [CrossRef]
39. Bartelt, R.; Sperling, J.W.; Schleck, C.D.; Cofield, R.H. Shoulder arthroplasty in patients aged fifty-five years or younger with osteoarthritis. *J. Shoulder Elb. Surg.* **2011**, *20*, 123–130. [CrossRef] [PubMed]
40. Deshmukh, A.V.; Koris, M.; Zurakowski, D.; Thornhill, T.S. Total shoulder arthroplasty: Long-term survivorship, functional outcome, and quality of life. *J. Shoulder Elb. Surg.* **2005**, *14*, 471–479. [CrossRef]
41. Edwards, T.B.; Kadakia, N.R.; Boulahia, A.; Kempf, J.F.; Boileau, P.; Nemoz, C.; Walch, G. A comparison of hemiarthroplasty and total shoulder arthroplasty in the treatment of primary glenohumeral osteoarthritis: Results of a multicenter study. *J. Shoulder Elb. Surg.* **2003**, *12*, 207–213. [CrossRef]
42. Foruria, A.M.; Sperling, J.W.; Ankem, H.K.; Oh, L.S.; Cofield, R.H. Total shoulder replacement for osteoarthritis in patients 80 years of age and older. *J. Bone Jt. Surg. Br.* **2010**, *92*, 970–974. [CrossRef] [PubMed]
43. Jost, P.W.; Dines, J.S.; Griffith, M.H.; Angel, M.; Altchek, D.W.; Dines, D.M. Total shoulder arthroplasty utilizing mini-stem humeral components: Technique and short-term results. *HSS J.* **2011**, *7*, 213–217. [CrossRef]

44. Khan, A.; Bunker, T.D.; Kitson, J.B. Clinical and radiological follow-up of the Aequalis third-generation cemented total shoulder replacement: A minimum ten-year study. *J. Bone Jt. Surg. Br.* **2009**, *91*, 1594–1600. [CrossRef]
45. Krishnan, S.G.; Nowinski, R.J.; Harrison, D.; Burkhead, W.Z. Humeral hemiarthroplasty with biologic resurfacing of the glenoid for glenohumeral arthritis. Two to fifteen-year outcomes. *J. Bone Jt. Surg. Am.* **2007**, *89*, 727–734. [CrossRef]
46. Levy, O.; Copeland, S.A. Cementless surface replacement arthroplasty of the shoulder. 5- to 10-year results with the Copeland mark-2 prosthesis. *J. Bone Jt. Surg. Br.* **2001**, *83*, 213–221. [CrossRef]
47. Levy, O.; Copeland, S.A. Cementless surface replacement arthroplasty (Copeland CSRA) for osteoarthritis of the shoulder. *J. Shoulder Elb. Surg.* **2004**, *13*, 266–271. [CrossRef] [PubMed]
48. Liu, J.N.; Garcia, G.H.; Gowd, A.K.; Mahony, G.; Sinatro, A.; Wu, H.H.; Dines, D.M.; Warren, R.F.; Gulotta, L.V. Return to Work After Shoulder Replacement for Glenohumeral Osteoarthritis Is Similar When Hemiarthroplasty Is Compared to Total Shoulder Arthroplasty. *HSS J.* **2020**, *16*, 212–217. [CrossRef]
49. Orfaly, R.M.; Rockwood, C.A., Jr.; Esenyel, C.Z.; Wirth, M.A. Shoulder arthroplasty in cases with avascular necrosis of the humeral head. *J. Shoulder Elb. Surg.* **2007**, *16* (Suppl. S3), S27–S32. [CrossRef]
50. Pfahler, M.; Jena, F.; Neyton, L.; Sirveaux, F.; Mole, D. Hemiarthroplasty versus total shoulder prosthesis: Results of cemented glenoid components. *J. Shoulder Elb. Surg.* **2006**, *15*, 154–163. [CrossRef] [PubMed]
51. Raiss, P.; Aldinger, P.R.; Kasten, P.; Rickert, M.; Loew, M. Total shoulder replacement in young and middle-aged patients with glenohumeral osteoarthritis. *J. Bone Jt. Surg. Br.* **2008**, *90*, 764–769. [CrossRef]
52. Rispoli, D.M.; Sperling, J.W.; Athwal, G.S.; Schleck, C.D.; Cofield, R.H. Humeral head replacement for the treatment of osteoarthritis. *J. Bone Jt. Surg. Am.* **2006**, *88*, 2637–2644. [CrossRef]
53. Robinson, W.A.; Wagner, E.R.; Cofield, R.H.; Sanchez-Sotelo, J.; Sperling, J.W. Long-term outcomes of humeral head replacement for the treatment of osteoarthritis; a report of 44 arthroplasties with minimum 10-year follow-up. *J. Shoulder Elb. Surg.* **2018**, *27*, 846–852. [CrossRef] [PubMed]
54. Sperling, J.W.; Cofield, R.H.; Rowland, C.M. Minimum fifteen-year follow-up of Neer hemiarthroplasty and total shoulder arthroplasty in patients aged fifty years or younger. *J. Shoulder Elb. Surg.* **2004**, *13*, 604–613. [CrossRef]
55. Sperling, J.W.; Cofield, R.H.; Schleck, C.D.; Harmsen, W.S. Total shoulder arthroplasty versus hemiarthroplasty for rheumatoid arthritis of the shoulder: Results of 303 consecutive cases. *J. Shoulder Elb. Surg.* **2007**, *16*, 683–690. [CrossRef] [PubMed]
56. Tammachote, N.; Sperling, J.W.; Vathana, T.; Cofield, R.H.; Harmsen, W.S.; Schleck, C.D. Long-term results of cemented metal-backed glenoid components for osteoarthritis of the shoulder. *J. Bone Jt. Surg. Am.* **2009**, *91*, 160–166. [CrossRef]
57. Taunton, M.J.; McIntosh, A.L.; Sperling, J.W.; Cofield, R.H. Total shoulder arthroplasty with a metal-backed, bone-ingrowth glenoid component. Medium to long-term results. *J. Bone Jt. Surg. Am.* **2008**, *90*, 2180–2188. [CrossRef]
58. Torchia, M.E.; Cofield, R.H.; Settergren, C.R. Total shoulder arthroplasty with the Neer prosthesis: Long-term results. *J. Shoulder Elb. Surg.* **1997**, *6*, 495–505. [CrossRef]
59. Walch, G.; Young, A.A.; Melis, B.; Gazielly, D.; Loew, M.; Boileau, P. Results of a convex-back cemented keeled glenoid component in primary osteoarthritis: Multicenter study with a follow-up greater than 5 years. *J. Shoulder Elb. Surg.* **2011**, *20*, 385–394. [CrossRef]
60. Wirth, M.A.; Tapscott, R.S.; Southworth, C.; Rockwood, C.A., Jr. Treatment of glenohumeral arthritis with a hemiarthroplasty: A minimum five-year follow-up outcome study. *J. Bone Jt. Surg. Am.* **2006**, *88*, 964–973. [CrossRef]
61. Young, A.; Walch, G.; Boileau, P.; Favard, L.; Gohlke, F.; Loew, M.; Mole, D. A multicentre study of the long-term results of using a flat-back polyethylene glenoid component in shoulder replacement for primary osteoarthritis. *J. Bone Jt. Surg. Br.* **2011**, *93*, 210–216. [CrossRef]
62. van de Sande, M.A.; Brand, R.; Rozing, P.M. Indications, complications, and results of shoulder arthroplasty. *Scand. J. Rheumatol.* **2006**, *35*, 426–434. [CrossRef] [PubMed]
63. Habermeyer, P.; Ebert, T. Current status and perspectives of shoulder replacement. *Unfallchirurg* **1999**, *102*, 668–683. [CrossRef]
64. Merolla, G.; Nastrucci, G.; Porcellini, G. Shoulder arthroplasty in osteoarthritis: Current concepts in biomechanics and surgical technique. *Transl. Med. UniSa* **2013**, *6*, 16–28.
65. Kronberg, M.; Brostrom, L.A.; Soderlund, V. Retroversion of the humeral head in the normal shoulder and its relationship to the normal range of motion. *Clin. Orthop. Relat. Res.* **1990**, *253*, 113–117.
66. Tannenbaum, E.; Sekiya, J.K. Evaluation and management of posterior shoulder instability. *Sports Health* **2011**, *3*, 253–263. [CrossRef] [PubMed]
67. Garth, W.P., Jr.; Allman, F.L., Jr.; Armstrong, W.S. Occult anterior subluxations of the shoulder in noncontact sports. *Am. J. Sports Med.* **1987**, *15*, 579–585. [CrossRef]
68. Matsen, F.A., 3rd; Clinton, J.; Lynch, J.; Bertelsen, A.; Richardson, M.L. Glenoid component failure in total shoulder arthroplasty. *J. Bone Jt. Surg. Am.* **2008**, *90*, 885–896. [CrossRef] [PubMed]
69. Merolla, G.; Campi, F.; Paladini, P.; Lollino, N.; Fauci, F.; Porcellini, G. Correlation between radiographic risk for glenoid component loosening and clinical scores in shoulder arthroplasty. *Chir. Organi. Mov.* **2009**, *93* (Suppl. S1), S29–S34. [CrossRef]
70. Nyffeler, R.W.; Meyer, D.; Sheikh, R.; Koller, B.J.; Gerber, C. The effect of cementing technique on structural fixation of pegged glenoid components in total shoulder arthroplasty. *J. Shoulder Elb. Surg.* **2006**, *15*, 106–111. [CrossRef]

71. Scully, W.F.; Crawford, D.A.; Brugman, S.C.; Manoso, M.W. Glenoid component failure after total shoulder arthroplasty with migration of the component into posterior subcutaneous tissue: A case report. *J. Surg. Orthop. Adv.* **2013**, *22*, 241–244. [CrossRef] [PubMed]
72. Parsons IMt Millett, P.J.; Warner, J.J. Glenoid wear after shoulder hemiarthroplasty: Quantitative radiographic analysis. *Clin. Orthop. Relat. Res.* **2004**, *421*, 120–125. [CrossRef]
73. Churchill, J.L.; Garrigues, G.E. Current Controversies in Reverse Total Shoulder Arthroplasty. *JBJS Rev.* **2016**, *4*. [CrossRef] [PubMed]
74. Verborgt, O.; El-Abiad, R.; Gazielly, D.F. Long-term results of uncemented humeral components in shoulder arthroplasty. *J. Shoulder Elb. Surg.* **2007**, *16* (Suppl. S3), S13–S18. [CrossRef]
75. Cil, A.; Veillette, C.J.; Sanchez-Sotelo, J.; Sperling, J.W.; Schleck, C.; Cofield, R.H. Revision of the humeral component for aseptic loosening in arthroplasty of the shoulder. *J. Bone Jt. Surg. Br.* **2009**, *91*, 75–81. [CrossRef]
76. Bishop, J.Y.; Flatow, E.L. Humeral head replacement versus total shoulder arthroplasty: Clinical outcomes—A review. *J. Shoulder Elb. Surg.* **2005**, *14* (Suppl. S1), 141S–146S. [CrossRef] [PubMed]
77. Gartsman, G.M.; Roddey, T.S.; Hammerman, S.M. Shoulder arthroplasty with or without resurfacing of the glenoid in patients who have osteoarthritis. *J. Bone Jt. Surg. Am.* **2000**, *82*, 26–34. [CrossRef] [PubMed]
78. Carroll, R.M.; Izquierdo, R.; Vazquez, M.; Blaine, T.A.; Levine, W.N.; Bigliani, L.U. Conversion of painful hemiarthroplasty to total shoulder arthroplasty: Long-term results. *J. Shoulder Elb. Surg.* **2004**, *13*, 599–603. [CrossRef]
79. Mather, R.C., 3rd; Watters, T.S.; Orlando, L.A.; Bolognesi, M.P.; Moorman, C.T., 3rd. Cost effectiveness analysis of hemiarthroplasty and total shoulder arthroplasty. *J. Shoulder Elb. Surg.* **2010**, *19*, 325–334. [CrossRef]
80. Denard, P.J.; Raiss, P.; Sowa, B.; Walch, G. Mid- to long-term follow-up of total shoulder arthroplasty using a keeled glenoid in young adults with primary glenohumeral arthritis. *J. Shoulder Elb. Surg.* **2013**, *22*, 894–900. [CrossRef]
81. Cil, A.; Veillette, C.J.; Sanchez-Sotelo, J.; Sperling, J.W.; Schleck, C.D.; Cofield, R.H. Survivorship of the humeral component in shoulder arthroplasty. *J. Shoulder Elb. Surg.* **2010**, *19*, 143–150. [CrossRef]
82. Bohsali, K.I.; Wirth, M.A.; Rockwood, C.A., Jr. Complications of total shoulder arthroplasty. *J. Bone Jt. Surg. Am.* **2006**, *88*, 2279–2292. [CrossRef]
83. Norris, T.R.; Iannotti, J.P. Functional outcome after shoulder arthroplasty for primary osteoarthritis: A multicenter study. *J. Shoulder Elb. Surg.* **2002**, *11*, 130–135. [CrossRef]
84. Denard, P.J.; Wirth, M.A.; Orfaly, R.M. Management of glenohumeral arthritis in the young adult. *J. Bone Jt. Surg. Am.* **2011**, *93*, 885–892. [CrossRef]
85. Fox, T.J.; Cil, A.; Sperling, J.W.; Sanchez-Sotelo, J.; Schleck, C.D.; Cofield, R.H. Survival of the glenoid component in shoulder arthroplasty. *J. Shoulder Elb. Surg.* **2009**, *18*, 859–863. [CrossRef]
86. Walch, G.; Young, A.A.; Boileau, P.; Loew, M.; Gazielly, D.; Mole, D. Patterns of loosening of polyethylene keeled glenoid components after shoulder arthroplasty for primary osteoarthritis: Results of a multicenter study with more than five years of follow-up. *J. Bone Jt. Surg. Am.* **2012**, *94*, 145–150. [CrossRef]
87. Kiet, T.K.; Feeley, B.T.; Naimark, M.; Gajiu, T.; Hall, S.L.; Chung, T.T.; Ma, C.B. Outcomes after shoulder replacement: Comparison between reverse and anatomic total shoulder arthroplasty. *J. Shoulder Elb. Surg.* **2015**, *24*, 179–185. [CrossRef]
88. Hawkins, R.J.; Bell, R.H.; Jallay, B. Total shoulder arthroplasty. *Clin. Orthop. Relat. Res.* **1989**, *242*, 188–194. [CrossRef]