SH85: What are the indications for one versus two-stage exchange arthroplasty in the management of subacute or chronic shoulder PJI?

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Response: There is no specific recommendation for single or dual-stage exchange in the management of sub-acute or chronic shoulder PJI.

Strength of Recommendation: Limited

Delegate Vote: 46 (100%) agree; 0 disagree; 0 abstain

Rationale: A comprehensive literature review was performed to identify all studies on revision shoulder arthroplasty for treatment of PJI. Searches for the terms "shoulder replacement", "arthroplasty," "postoperative," "infection," "revision", "reimplantation," "one stage," "1-stage," "two stage," "2-stage," "prosthetic-related infection" amongst others were performed using the search engines PubMed, Scopus, and Google Scholar which were searched through November 2024. Inclusion criteria for our systematic review were all English studies (Level I-IV evidence) that reported on infection eradication rates for single or two-stage revision arthroplasty for PJI of the shoulder with a minimum of one year of follow-up. We defined single-stage revision arthroplasty as a complete removal of components followed by irrigation and debridement and reimplantation of prosthetic components in the same procedure. We defined two-stage revision as patients who underwent an initial procedure to remove the existing prosthetic components, irrigation and debridement, and antibiotic spacer placement, followed by a second procedure to remove the spacer, repeat irrigation and debridement, and reimplantation of prosthetic components. Exclusion criteria were non-English language articles, studies not reporting on infection eradication, studies without 12 months of clinical follow-up, review papers, and technique papers without patient data. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) criteria were followed. 48 articles were identified that met inclusion and exclusion criteria for final review.

Two-stage exchange arthroplasty has been considered the gold standard for treatment of PJI of the shoulder.[6] Recently, one-stage exchange arthroplasty has been advocated for as several studies have reported lower complication rates compared to two-stage exchange as well as similar reinfection rates.[2,7,9,13] The purpose of this review was to compare the outcomes of single-stage versus two-stage exchange arthroplasty and their role in treatment of acute shoulder PJI.

We identified 18 articles that evaluated one-stage exchange arthroplasty and 39 articles that evaluated two-stage exchange arthroplasty for treatment of shoulder PJI. Studies diagnosed PJI based on the previous ICM guidelines.[5] Patient demographics, surgical treatment method, rate of reinfection, and non-infection related complications were consistently reported amongst the studies included. Other variables including timing of infection, associated pathogens, clinical findings (ie: draining sinus, erythema, etc), antibiotic treatment, and functional outcomes were inconsistently reported. In studies that did report timing of infection this was defined according

to Sperling et al. and Strickland et al. with acute meaning < 3 months from primary arthroplasty, sub-acute meaning 3-12 months, and chronic > 12 months.[17,18]

To address the question of the role of one versus two-stage exchange in shoulder PJI we reviewed the data on infection eradication/reinfection rates in single and two-stage procedures as defined above and evaluated complication rates and functional outcomes. Studies were grouped according to their revision type (single-stage or two-stage). Studies with both single and two stage revisions were separated into two different groups. Number of reinfections and sample sizes were extracted to calculate the proportion of reinfections on follow-up. A proportional meta-analysis using a fixed-effects (sample size) model with double arcsine transformation (Freeman-Tukey) was conducted to identify the pooled rate of reinfections with 95% confidence intervals for single-stage and two-stage separately. Confidence intervals were compared and a p-value was calculated. Weighted means for continuous outcomes (forward flexion, external rotation and Constant Murley Score) were calculated. Weighted means were not compared between surgery types. All analysis were performed using JBI SUMARI.

Out of the 48 studies included in this systematic review, 18 studies had a single-stage group and 39 studies had a two-stage group (9 studies with both arms). The pooled incidence of reinfection was 2.7% (1.0%, 5.0%) in single-stage studies and 12.5% (9.8%,15.3%) for two-stage surgeries, which is statistically significant ($p < 0.001$) (Table 1). The most common organisms identified were C. acnes, Coagulase negative staph species, MRSA, MSSA, and Staph Epidermidis. We identified 6 studies that evaluated single-stage exchange for treatment of subacute or chronic PJI.[2,4,7,9,10,16] These studies reported on 76 patients with 5 reinfections. For two-stage exchange we identified 8 studies that evaluated two-stage exchange for treatment of subacute or chronic PJI.[3,4,8,10,11,14,15,19] These studies reported on 101 patients with 11 reinfections. These studies are summarized in Table 2.

Analysis of non-infectious related complication rate and functional outcomes for single and two-stage exchange related to timing of infection was limited. The pooled non-infectious related complication rate was 11.9% (7.7%, 16.7%) in the single-stage group and 21.4% (17.6%, 25.4%) for the two-stage group, which is statistically significant ($p = 0.003$) (Table 1). Complications included periprosthetic fracture (intra or post-operative), aseptic loosening, nerve palsy, instability, and hematoma formation. Functional outcomes are also summarized in Table 1 however, weighted means could not be compared. Additional outcome measures including ASES score, UCLA score, SST, DASH score, Penn Shoulder Score, and VAS pain and function were reported in a highly variable fashion amongst the studies included.

While the data on pooled reinfection rate and pooled non-infectious complication rate may suggest single-stage exchange is superior to two-stage exchange, the current analysis was not able to account for selection bias in the studies included. There is certainly a possibility that patients treated with two-stage exchange had more severe infections compared to those treated with single-stage and the selection bias this imparts should not be overlooked.

Another limitation of the current review was the duration of follow-up. We included studies with a minimum of one year follow up however, follow-up was highly variable from study to study and even within studies. 38 studies had reported mean follow-up duration > 2 years. Despite this, long-term studies evaluating reinfection rate at 5 and 10 years are lacking. Sevelda et al reported on 14 patients who underwent one-stage exchange for PJI with mean 5.8 years of follow-up. 0/14 patients had reinfection at one year and 1/8 patients had evidence of reinfection at 5 years.[16] Ince et al reported on 16 patients who underwent single-stage exchange. 5 patients had no evidence of reinfection at 5 years and two of these patients did not demonstrate

evidence of reinfection at 10 years.[7] Akgun et al reported on 35 patients undergoing two-stage exchange arthroplasty at mean 5.1 years of follow-up (range 1.1-10.1). Of these, 5 patients experienced reinfection and required further revision surgery.[1] Meshram et al evaluated 17 patients who underwent two-stage revision with minimum 5 year follow-up (5-9 years) with 3/17 patients experiencing a reinfection (17.6%).[12] Long-term follow up is crucial for evaluating the efficacy of single versus two-stage exchange for shoulder PJI, particularly in cases of infection with an indolent course such as those caused by C. acnes which was the most common pathogen in our review. The delayed presentation of infection may cause some treatment failures to be missed at the short to intermediate term timeframes.

Overall, this review demonstrates a substantial gap in the current literature regarding single versus two-stage exchange arthroplasty for treatment of shoulder PJI. Of the 48 articles included two were prospective cohort studies and the remainder were retrospective reviews, thus selection bias is a concern. When specifically evaluating treatment of subacute or chronic PJI using single or two-stage exchange, the current number of cases reported in the literature that identify reinfection rate, complication rate, and functional outcomes in relation to timing of infection is insufficient.

Table 1. Reinfection, complication, and functional outcomes.

One-Stage	**Pooled Reinfection Rate**	**Pooled Non-infectious Related Complication Rate**	**Constant-Murley Score**	**Forward Flexion (Degrees)**	**External Rotation (Degrees)**
18 Papers	2.7% (1.0%, 5.0%) $p < 0.001$	11.9% (7.7%, 16.7%) $p = 0.003$	50.76 +/- 7.48	111.79 +/- 15.79	27.25 +/- 7.87
Two-Stage	**Pooled Reinfection Rate**	**Pooled Non-infectious Related Complication Rate**	**Constant-Murley Score**	**Forward Flexion (degrees)**	**External Rotation (Degrees)**
39 Papers	12.5% (9.8%, 15.3%) $p < 0.001$	21.4% (17.6%, 25.4%) $p = 0.003$	46.82 +/- 10.10	105.61 +/- 19.43	33.04 +/- 12.93

Table 2. Summary of reinfections and complications for studies evaluating one and two-stage exchange for treatment of subacute or chronic PJI.

One-Stage	Study	Reinfection	Complication
6 Papers	Beekman et al.	1/10	2/10
	Dodson et al.	1/6	NR
	Ince et al.	0/14	1/14
	Klatte et al.	2/31	NR
	Lemmens et al.	0/1	NR
	Sevelda et al.	0/14 @ 1 year, 1/8 @ 5 years	1/14
Two-Stage	**Study**	**Reinfection**	**Complication**
8 Papers	Buchalter et al.	4/18	2/18
	Dodson et al	2/5	NR
	Jerosch et al	0/10	NR
	Lemmens et al	0/16	NR
	Magnan et al	0/2	0/2
	Sabesan et al	1/17	5/17
	Saccomanno et al	1/13	NR
	Torrens et al.	3/20	NR
NR = Not Reported			

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