

## THE SYSTEMATIC REVIEW OF OUTCOME AFTER RECONSTRUCTION OF THE PROXIMAL HUMERUS FOR TUMOR RESECTION

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### ABSTRACT

**Background:** Orthopaedic oncologists often encounter malignant tumors of the proximal humerus, which are the third most common location for bone and soft tissue tumors. These tumors present more therapeutic difficulties in terms of local control and future repair than those in other locations. Each surgical techniques have advantages and disadvantages. It has different outcomes.

**The aim:** This study aims to show the outcomes after reconstruction of the proximal humerus for tumor resection.

**Methods:** By comparing itself to the standards set by the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) 2020, this study was able to show that it met all of the requirements. So, the experts were able to make sure that the study was as up-to-date as it was possible to be. For this search approach, publications that came out between 2014 and 2024 were taken into account. Several different online reference sources, like PubMed and ScienceDirect, were used to do this. It was decided not to take into account review pieces, works that had already been published, or works that were only half done.

**Results:** In the PubMed database, the results of our search brought up 125 articles, whereas the results of our search on ScienceDirect brought up 141 articles. The results of the search conducted by title screening yielded a total 26 articles for PubMed and 32 articles for ScienceDirect. We compiled a total of 29 papers, 12 of which came from PubMed and 17 of which came from ScienceDirect. We excluded 2 review articles, 9 duplicate articles, 1 non-full text article, and 2 articles having ineligible outcomes data. In the end, we included fifteen research that met the criteria.

**Conclusion:** Reverse shoulder arthroplasty showed potential for best functional outcomes and no local recurrence occurred during follow-up period. Whereas endoprosthesis and allograft-prosthesis showed lowest complications rates. However, further investigation is needed.

**Keywords:** Reconstruction, surgery, proximal humerus, tumor resection, outcome

## INTRODUCTION

Orthopaedic oncologists frequently get presentations of malignant tumours of the proximal humerus.<sup>1</sup> The proximal humerus is the third most common location for bone and soft tissue tumors, and the second most common location of primary malignant bone tumors such as chondrosarcoma, Ewing's sarcoma, and osteosarcoma.<sup>1,2</sup> Additionally, benign locally aggressive primary bone tumours such giant cell tumours (GCT) and aneurysmal bone cysts (ABC) frequently occur in the proximal humerus. Lesions from multiple myeloma or metastatic bone disease can frequently be found in this region.<sup>2</sup>

Tumours in the shoulder girdle and proximal humerus present more therapeutic difficulties in terms of local control and future repair than tumours in other places.<sup>2</sup> It is essential to give the oncologic issue top priority when managing it.<sup>1</sup> After obtaining the biopsy specimen, a multidisciplinary discussion determines the surgical technique. It is essential to give the oncologic issue top priority when managing it, whether the purpose of the surgery is palliative or curative.<sup>1,3</sup> In the event where neo-adjuvant therapy was administered, more imaging tests are conducted. The imaging studies serve to assess the extent of the resection and the margins according to the classification system developed by Malawer et al.<sup>3</sup>

Large bone and soft tissue resections are frequently required during upper limb sparing surgery in order to provide broad surgical margins free of disease. If left untreated, the tissue loss may cause impairments to the arm and shoulder from both a static and dynamic perspective. The articular range of motion (ROM) of the shoulder and the arm's length and form are critical for upper limb functionality, which is essential for restoring patients' autonomy and improving their quality of life after surgery.<sup>4</sup>

Many surgical techniques have been developed throughout the years to restore the deficiency after the proximal humerus tumor was removed; each technique has advantages and disadvantages. With the development of imaging, clinical oncology, and surgical procedures, it is now possible to do a meticulous surgical resection in the era of limb preservation, with a higher likelihood of favorable oncological results and negative surgical margins.<sup>5,6</sup> However, the optimal form of reconstruction after resection remains controversial because the amount of muscle lost following tumor removal, available surgical expertise, and the financial limits in various health systems. Important surgical goals include returning the limb's length and shape and shoulder mobility so that the patient can carry out daily tasks. This study aims to show the outcomes after reconstruction of the proximal humerus for tumor resection.

## METHODS

### Protocol

By following the rules provided by Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) 2020, the author of this study made certain that it was up to par with the requirements. This is done to ensure that the conclusions drawn from the inquiry are accurate.

### Criteria for Eligibility

For the purpose of this systematic review, we investigate the outcome after reconstruction of the proximal humerus for tumor resection. It is possible to accomplish this by researching or investigating the functional outcomes, complications, and local recurrence rates. As the primary purpose of this piece of writing, demonstrating the relevance of the difficulties that have been identified will take place throughout its entirety.

In order for researchers to take part in the study, it was necessary for them to fulfil the following requirements: 1) The paper needs to be written in English, and it should focus on determining the outcome after reconstruction of the proximal humerus for tumor resection. In order for the manuscript to be considered for publication, it needs to meet both of these requirements. 2) The studied papers include several that were published within the last 10 years. Examples of studies that are not permitted include editorials, submissions that do not have a DOI, review articles that have already been published, and entries that are essentially identical to journal papers that have already been published.

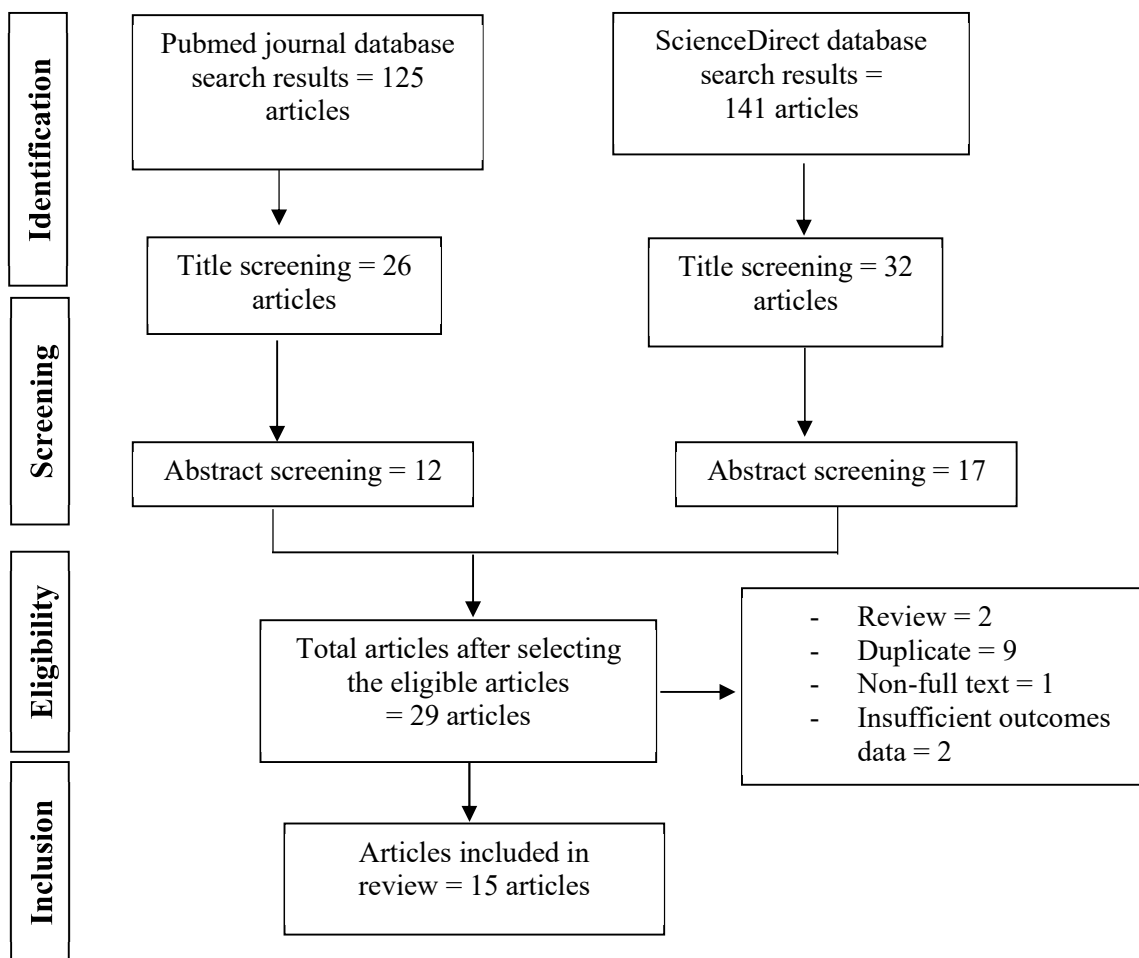
### Search Strategy

We used "reconstruction"; "surgery"; "proximal humerus"; "tumor resection"; and "outcome" as keywords. The search for studies to be included in the systematic review was carried out from January, 5th 2024 using the PubMed and ScienceDirect databases by inputting the words: "plastic surgery procedures"[MeSH Terms] OR ("plastic"[All Fields] AND "surgery"[All Fields] AND "procedures"[All Fields] OR "plastic surgery procedures"[All Fields] OR "reconstruction"[All Fields] OR "reconstructions"[All Fields] OR "reconstruct"[All Fields] OR "reconstructability"[All Fields] OR "reconstructable"[All Fields] OR "reconstructed"[All Fields] OR "reconstructible"[All Fields] OR "reconstructing"[All Fields] OR "reconstructional"[All Fields] OR "reconstructive"[All Fields] OR "reconstructs"[All Fields] OR "surgery"[MeSH Subheading] OR "surgery"[All Fields] OR "surgical procedures, operative"[MeSH Terms] OR ("surgical"[All Fields] AND "procedures"[All Fields] AND "operative"[All Fields] OR "operative surgical procedures"[All Fields] OR "general surgery"[MeSH Terms] OR "general"[All Fields] AND "surgery"[All Fields] OR

"general surgery"[All Fields] OR "surgery s"[All Fields] OR "surgeries"[All Fields] OR "surgeries"[All Fields] AND "proximal"[All Fields] OR "proximalization"[All Fields] OR "proximalize"[All Fields] OR "proximalized"[All Fields] OR "proximalizes"[All Fields] OR "proximalizing"[All Fields] OR "proximally"[All Fields] OR "proximals"[All Fields] AND ("humerus"[MeSH Terms] OR "humerus"[All Fields])) AND "cysts"[MeSH Terms] OR "cysts"[All Fields] OR "cyst"[All Fields] OR "neurofibroma"[MeSH Terms] OR "neurofibroma"[All Fields] OR "neurofibromas"[All Fields] OR "tumor s"[All Fields] OR "tumoral"[All Fields] OR "tumorous"[All Fields] OR "tumour"[All Fields] OR "neoplasms"[MeSH Terms] OR "neoplasms"[All Fields] OR "tumor"[All Fields] OR "tumour s"[All Fields] OR "tumoural"[All Fields] OR "tumourous"[All Fields] OR "tumours"[All Fields] OR "tumors"[All Fields] AND ("resect"[All Fields] OR "resectability"[All Fields] OR "resectable"[All Fields] OR "resectates"[All Fields] OR "resected"[All Fields] OR "resecting"[All Fields] OR "resection"[All Fields] OR "resectional"[All Fields] OR "resectioned"[All Fields] OR "resectioning"[All Fields] OR "resections"[All Fields] OR "resective"[All Fields] OR "resects"[All Fields])) AND ("outcome"[All Fields] OR "outcomes"[All Fields])) AND (y\_10[Filter]) AND (english[Filter]) used in searching the literature.

**Data retrieval**

After reading the abstract and the title of each study, the writers performed an examination to determine whether or not the study satisfied the inclusion criteria. The writers then decided which previous research they wanted to utilise as sources for their article and selected those studies. After looking at a number of different research, which all seemed to point to the same trend, this conclusion was drawn. All submissions need to be written in English and can't have been seen anywhere else.



**Figure 1. Article search flowchart**

Only those papers that were able to satisfy all of the inclusion criteria were taken into consideration for the systematic review. This reduces the number of results to only those that are pertinent to the search. We do not take into consideration the conclusions of any study that does not satisfy our requirements. After this, the findings of the research will be analysed in great detail. The following pieces of information were uncovered as a result of the inquiry that was carried out for the purpose of this study: names, authors, publication dates, location, study activities, and parameters.

**Quality Assessment and Data Synthesis**

Each author did their own study on the research that was included in the publication's title and abstract before making a decision about which publications to explore further. The next step will be to evaluate all of the articles that are suitable for inclusion in the review because they match the criteria set forth for that purpose in the review. After that, we'll determine which articles to include in the review depending on the findings that we've uncovered. This criteria is utilised in the process of selecting papers for further assessment in order to simplify the process as much as feasible when selecting papers to evaluate. Which earlier investigations were carried out, and what elements of those studies made it appropriate to include them in the review, are being discussed here.

**RESULT**

In the PubMed database, the results of our search brought up 125 articles, whereas the results of our search on ScienceDirect brought up 141 articles. The results of the search conducted by title screening yielded a total 26 articles for PubMed and 32 articles for ScienceDirect. We compiled a total of 29 papers, 12 of which came from PubMed and 17 of which came from ScienceDirect. We excluded 2 review articles, 9 duplicate articles, 1 non-full text article, and 2 articles having ineligible outcomes data. In the end, we included fifteen research that met the criteria.

**Table 1. The literature include in this study**

Author	Origin	Method	Sample Size	Result
Antal, 2023 <sup>7</sup>	Hungary	Retrospective study	90 patients	This findings suggested that the implantation of a reverse shoulder prosthesis-allograft provides excellent functional outcomes, especially in young adults. The best range of motion was observed following arthroplasty with a reverse shoulder prosthesis-homograft composite. Revision surgery was required due to major complications most frequently in the osteoarticular allograft group. MSTS was 84% on average for the reverse shoulder prosthesis-allograft composite group. Using the SF-36 questionnaire for assessment no significant differences were found between the four groups regarding quality of life.
Bonnevialle, 2015 <sup>8</sup>	France	Retrospective study	21 patients	This results showed that use of reverse shoulder arthroplasty (RSA) after resection of a malignant tumor of the proximal humerus seems to be an acceptable option to preserve function. Nevertheless, radiographic evolution is worrisome, and long-term study remains necessary to validate this therapeutic option with follow-up.

Gulia, 2021 <sup>9</sup>	India	Retrospective study	142 patients	This findings suggested that implant cement spacer (NCS/PCS) offers a simple, cost-effective, and reliable alternative in proximal humerus resection when oncological concerns necessitate sacrifice of proximal humerus motors and/or the axillary nerve.
Güven, 2016 <sup>10</sup>	Turkey	Retrospective study	10 patients	The results concluded a stable shoulder joint and functionally satisfying results can be achieved by using an reverse shoulder tumor prosthesis (RSTP) without the need for a proximal humeral allograft in the treatment of proximal humerus tumors. An intact abductor mechanism with a shorter humeral resection length strongly influences the results. Especially in cases in which the patient's comorbidities demand a shorter operative time, this prosthesis can be an appropriate choice.
Hu, 2019 <sup>11</sup>	China	Retrospective study	7 patients	This findings showed RSA based on a 3D-printed glenoid prosthesis and a personalized custom-made humerus prosthesis significantly improved the shoulder function and decreased the complication rate.
Jamshidi, 2017 <sup>12</sup>	Iran	Retrospective study	36 patients	The results concluded that cement augmentation improves survival and reduces the complication rate of allografts. In addition, anteromedial placing of the plate in resection type IB could improve the functional outcome of allografts.
Kapoor, 2021 <sup>13</sup>	India	Retrospective study	25 patients	This findings suggested the use of Prolene mesh for soft tissue reconstruction following resection of bone tumors enhances the stability of the skeletal reconstruct without any increase in the risk of wound dehiscence or deep infection. Prolene mesh is a boon for orthopaedic onco-surgeons and an extremely useful tool to reconstruct the soft tissues especially in a developing country like ours. It is readily available, reliable and provides reproducible results.

Liang, 2022 <sup>14</sup>	China	Retrospective study	10 patients	This results showed that the new arthrodesis prosthesis or 3D-printed arthrodesis prosthesis could be an alternative method for functional reconstruction could be an alternative method for the reconstruction of bone defects after resection of a proximal humeral tumor, especially for patients without preservation of the axillary nerve.
Liu, 2014 <sup>15</sup>	China	Retrospective study	41 patients	This study showed that prosthetic reconstruction and reconstruction with recycled pasteurized autograft are similar in terms of their local recurrence and metastasis, while the incidence of revisions was higher for patients with prosthetic reconstruction.
Motassime, 2023 <sup>16</sup>	Italy	Retrospective observational study	20 patients	This results showed that reconstructive surgery with megaprosthesis of the proximal humerus in patients with metastases can be considered a treatment option, especially in patients with pathological fractures or injuries with a high risk of fracture and good life expectancy. Reconstructive surgery with megaprosthesis affects instability, but it gives satisfactory results in terms of functionality, pain, and patient satisfaction.
Nota, 2018 <sup>17</sup>	USA	Retrospective cohort	150 patients	This findings suggested the articular methods of reconstruction such as the osteoarticular allografts (OA), endoprostheses (EP), and allograft-prosthesis composites (APC) are comparable in terms of function and complication rates are comparable. This study confirmed a higher fracture rate in OAs than their counterparts. This higher fracture rate explains the observed higher revision rate and apparent lower survival rate compared with endoprostheses or APCs.

Ogink, 2019 <sup>18</sup>	USA	Retrospective study	84 patients	This findings showed that allograft reconstructions of the humerus had good functional outcome and implant survival rates similar to other modalities. However, surgeons should mind the relatively high accompanying complication rates. Allograft fractures seem to be the main issue for proximal and distal allografts, which often leads to either reoperation or revision surgery.
Rafalla, 2017 <sup>19</sup>	Egypt	Retrospective study	20 patients	This results showed that the functional outcome was comparable in endoprosthetic replacement and cement spacer. However, cement spacer can give significant reduction in cost.
Vonck, 2023 <sup>20</sup>	USA	Retrospective study	20 patients	This findings suggested that complication rates and ROM following oncologic RTSA were worse than reported in prior studies, while PROMs were lower. The RTSA remains a viable treatment option for oncologic processes about the glenohumeral joint in appropriate patients.
Wang, 2015 <sup>21</sup>	China	Retrospective study	18 patients	The results showed that the endoprosthesis reconstruction on the basis of nonabsorbable PPP mesh can significantly reduce the rate of glenohumeral joint instability and dislocation and improve patient's quality of life.

**Complications**

One of fifteen identified studies, Kapoor, et al. (2021)<sup>13</sup> showed that there was no complication noted including mechanical failure (type 1A failure-instability and extension lag) and biological failure (type 1B failure of soft tissue coverage and type 4 failure with deep infection) in patients with proximal humerus endoprosthesis/nail cement spacer reconstruction.

Antal, et al. (2023)<sup>7</sup> showed that six developed complications (24%) in the autologous fibula transplantation group. Four complications (40%) occurred in the group of 10 patients who received a massive osteoarticular allograft. In the reverse shoulder prosthesis-allograft group of 12 patients the only type of complication observed was instability (Henderson Type 1/A). In the reverse shoulder prosthesis-allograft group of 12 patients the only type of complication observed was instability (Henderson Type 1/A), six cases of luxation occurred within the first 4 postoperative weeks. And the lowest complication rate among all groups, namely 14% (6 cases) was in endoprosthesis (conventional humerus hemiarthroplasty) group. Infections occurred in osteoarticular allograft and endoprosthesis groups. However, the infection was successfully managed by graft excision and debridement.

Bonnevialle, et al. (2015)<sup>8</sup> showed four complications occurred in 3 patients (an intraoperative brachial plexus injury, anterior dislocation, and inferior dislocation. Gulia, et al. (2021)<sup>9</sup> showed superficial skin necrosis was seen in three patients (Clavien Dindo grade 1), one patient of NCS with infection needed a wound lavage (Clavien Dindo grade 3B), one patient with NCS with proximal migration, nine patients with NCS and three patients with PCS who had asymptomatic proximal migration of the implant at the shoulder and one patient with NCS who had inferior subluxation of the implant noted on radiographs (n = 13, 9%).



Güven, et al. (2016)<sup>10</sup> showed 2 patients had prosthetic luxation on days 5 and 14, respectively after RSA. Both cases required open reduction. One of the patients used linked glenoid had mild pain. The others' VAS scores were 0. All 3 had lower range of motion compared with the other patients. An inferior instability was diagnosed in patient 9 at 10 months postoperatively. This patient complained about clicking in her shoulder when she was lifting her baby. Prominent anterior deltoid atrophy and loss of active elevation were identified in 1 patient.

Hu, et al. (2019)<sup>11</sup> showed that during the short-term follow-up period, no complications associated with the reconstruction procedure, such as infection, scapular notching, aseptic loosening, periprosthetic fractures or dislocation, were observed. However, one patient developed pulmonary metastasis (16 months after surgery), and one patient died due to pulmonary metastasis 15 months after surgery.

Jamshidi, et al. (2017)<sup>12</sup> showed that the different complication rate in cemented versus non-cemented allografts was statistically significant ( $p = 0.001$ ). There were 12 complications were observed during the follow-up period, which included 3 fractures, 4 resorptions, 3 infections and 2 nonunions. Only 4 out of 12 complications occurred in 26 cemented allografts, which included 1 fracture, 1 resorption, 1 infection and 1 nonunion. The other 8 complications occurred in 10 non-cemented allografts.

Liang, et al. (2022)<sup>14</sup> showed that two cases (20.0%) experienced detachment at the taper. One patient was disease-free and refused further operations for reduction of the prosthesis, while the other patient also had tumor recurrence and was treated by forequarter amputation. Liu, et al. (2014)<sup>15</sup> showed there were 25% patients acquired secondary iliac crest cancellous bone grafting to achieve union and one patient (6.25%) had a fracture because of slipping to the ground. This was changed the internal fixator and the fracture subsequently united uneventfully.

Nota, et al. (2018)<sup>17</sup> showed that fractures (49% [osteoarticular allografts; OA] versus 4.8% [EP] versus 10% [APC];  $P = 0.001$ ), component loosening (11% [OA] versus 1.2% [endoprostheses; EP] versus zero [allograft-prosthesis composites; APC];  $P = 0.032$ ), and nonunion (11% [OA] versus zero [EP] versus 5.0% [APC];  $P = 0.007$ ) of the reconstruction were more common in the OA group. No differences exist in postoperative infection, subluxation and dislocation, proximal humerus migration, or nerve and wound complications among the different reconstruction techniques.

Ogink, et al. (2019)<sup>18</sup> showed that fifty-one (61%) patients had at least one complication, 33 (39%) had one complication, nine (11%) had two complications, and nine (11%) had three complications or more. There were 18 fractures (21%), 14 (17%) nonunions, 10 (12%) hardware failures, 17 (20%) subluxations, five (6%) infections, three (3.6%) dislocations, three (3.6%) proximal migrations, two (2.4%) wound complications, and one (1.2%) malunion. Fracture and subluxation were the most common complication in the proximal and distal group (respectively, 28% and 29% in both groups), and nonunion and hardware failure in the intercalary group (both 23%). A comparison of the complications by group yielded no statistically significant difference between the groups for the mutual complications—infection ( $P = 0.48$ ), fracture ( $P = 0.13$ ), malunion ( $P = 0.44$ ), and nonunion ( $P = 0.50$ )—or the general complication rate ( $P = 0.62$ ).

Vonck, et al. (2023)<sup>20</sup> showed a total of 7/20 (35%) of patients experienced a complication postoperatively, this includes those individuals who received chemotherapy and radiation. Of which, 4/20 (20%) of patients experienced a dislocation (Henderson I), 3/20 (15%) developed aseptic loosening (Henderson II), 1/20 (5%) had a periprosthetic fracture (Henderson III), and 1/20 (5%) had a periprosthetic joint infection (Henderson IV). There were no recurrences (Henderson V). One of twenty (5%) patients sustained a radial nerve injury. All patients that experienced a complication according to the Henderson classification underwent reoperation.

Rafalla, et al. (2017)<sup>19</sup> showed four (20%) cases had complications, including three with chest metastasis and one with local recurrence, and one case of the endoprosthetic group had subluxation. Wang, et al. (2015)<sup>21</sup> showed that prosthesis loosening occurred in one patient (1/16) who often lifted heavy weights, and the patient had to undergo the revision surgery. In one patient (1/16; 6.25%) who underwent endoprosthesis- PPP mesh composite reconstruction as a revision surgery, the prosthetic humeral head moved upward a little three months after operation, and the "anterior subluxations" were not changed at the last follow-up. In this study, infection, periprosthetic fracture and shoulder dislocation were not observed.

### Functional Outcomes: Musculoskeletal Tumor Society (MSTS) score

Antal, et al. (2023)<sup>7</sup> showed that the best scores were found in the reverse shoulder prosthesis—bone allograft composite group, the score was 84%. Whereas MSTS score in the autologous fibula transplantation group was MSTS score was 70%. The patients in the tumor endoprosthesis group and the massive osteoarticular allograft group achieved similar, though somewhat lower scores: 67 and 64% respectively. Gulia, et al. (2021)<sup>9</sup> showed that the overall mean MSTS score was 71% (60 - 80%). The mean MSTS score for intramedullary nail (NCS) and a plate (PCS) was 71% and 72% respectively. Güven, et al. (2016)<sup>10</sup> showed the mean MSTS score was 78.1% (range, 50%-93%). Hu, et al. (2019)<sup>11</sup> showed that the mean MSTS functional outcome score was 85.7% (range, 73.3% to 93.3%)

Jamshidi, et al. (2017)<sup>12</sup> showed a significant difference was observed between the mean MSTS score and resection type ( $p = 0.001$ ). In this regard, mean MSTS score found to be  $87.6 \pm 3.39$  in type 1A and  $82.2 \pm 3.29$  in type



IB. Mean MSTS score found to be 84.9%, ranging from 76 to 90%. MSTS score was also significantly higher in benign tumors ( $p = 0.03$ ). Whereas Kapoor, et al. (2021)<sup>13</sup> showed lower mean MSTS 93 score in their study: 22.16% (19-25).

Liang, et al. (2022)<sup>14</sup> showed the mean MSTS-93 score were  $24.9 \pm 3.1$ . The mean forward flexion and abduction angles were  $71.3 \pm 19.4^\circ$  and  $61.3 \pm 16.4^\circ$ , respectively. Loss of the axillary nerve did not significantly decrease the MSTS-93 score (25.0 vs. 24.8,  $p = 0.919$ ) or the ranges of flexion ( $66.3^\circ$  vs.  $76.3^\circ$ ,  $p = 0.509$ ) and abduction ( $55.0^\circ$  vs.  $67.5^\circ$ ,  $p = 0.317$ ). These outcomes of functional status were obtained from 8 patients at more than 24 months postoperatively. Liu, et al. (2014)<sup>15</sup> showed that the differences between prosthesis and biological groups were not statistically significant,  $P = 0.756$ . The mean MSTS score was 63.6% in group prosthesis and 63.0% in group biological reconstruction.

Motassime, et al. (2023)<sup>16</sup> showed that megaprosthesis reconstruction shows fairly good results, especially regarding pain, function, and emotional acceptance. Moreover, mean MSTS was 57.6% ( $\pm 26.24$ ). Nota, et al. (2018)<sup>17</sup> showed that the MSTS ranges reported in previous review of the literature are comparable with their functional cohort ( $n = 21$ ; mean, 64%; range, 53% to 80%; IQR, 73% to 87%). Rafalla, et al. (2017)<sup>19</sup> showed that the overall functional outcome of endoprosthetic replacement and cement spacer groups was 65% (range 55–70%). There was no statistically significant relation were observed between the age, sex, type of the lesion, type of resection, and axillary nerve affection and the overall functional outcome ( $p = 0.100$ ,  $p = 0.510$ ,  $p = 0.235$ ,  $p = 0.220$ , and  $p = 0.331$ ). Vonck, et al. (2023)<sup>20</sup> showed that most patients achieved near functional shoulder ROM postoperatively. Mean PROMs were MSTS score 12/30 (0-27/30). Wang, et al. (2015)<sup>21</sup> showed that mean MSTS upper extremity functional outcome score was 67 %.

### Local Recurrence Rates

Three of identified studies using reverse shoulder arthroplasty showed there were no local recurrence in the follow-up period.<sup>10,11,20</sup> Whereas Wang, et al. (2015)<sup>21</sup> and Bonneville, et al. (2015)<sup>8</sup> also showed local recurrence occurred in one patient. Liu, et al. (2014)<sup>15</sup> showed local recurrences were occurred in 3 cases (12.0%) in prosthesis group and 2 cases (12.5%) in biological reconstruction group. Liang, et al. (2022)<sup>14</sup> also showed that local recurrence occurred in 2 cases with time to recurrence (month, mean  $\pm$  SD)  $20.3 \pm 7.6$ .

### DISCUSSION

Proximal humerus represents 7–10% of cases of both primary bone tumors and secondary malignancies, placing it as the third most common site.<sup>22</sup> The tumors included pleomorphic liposarcoma, leiomyosarcoma, osteosarcoma, giant cell tumor, multiple myeloma, chondrosarcoma, diffuse large B cell lymphoma, metastatic disease, etc.<sup>5,6</sup> The standard therapy for primary bone tumors is a broad excision of the tumor that includes the surrounding soft tissues in addition to the damaged bone.<sup>22</sup> Several reconstructive techniques are used to restore limb function following severe bone excision. Every reconstructive technique has benefits and drawbacks. When assessing a reconstruction method, factors including procedure simplicity, functional outcome, morbidity, problems, and durability should be taken into account. Tumor endoprosthesis, arthrodesis implants, autografts, allografts, and custom-made implants are the most commonly used.<sup>23</sup>

The purpose of this research was to review studies published after January of 2014 and up to January of 2024 that investigated the outcome after reconstruction of the proximal humerus for tumor resection. The MSTS scoring system is used to assess function and quality of life in patients undergoing oncological surgery for musculoskeletal tumors. The MSTS score consists of six items: pain, function, emotional, external support, functional independence, and gait. Each was rated with a score from 0 to 5. A higher score indicates a better function. This score can be converted to a scale from 0 to 100 points.<sup>24</sup> Reverse shoulder arthroplasty (RSA) showed potential for best functional outcomes and no local recurrence occurred during follow-up period. The range of MSTS score is large, from 64% - 90%.

The mechanism of RSA involves the deltoid muscle's mechanical action, which lifts the arm. It was first developed for rotator cuff tears in arthritic shoulder patients. Its use in shoulder reconstruction after tumour resection seems logical, given the sacrifice of the rotator cuff muscles. The MSTS score was satisfactory regardless of the type of resection, but did not satisfactorily discriminate the influence of muscle sacrifice.<sup>25</sup> In a study on reconstructions with composite prostheses, Teunis et al. found a majority of MSTS scores between 60 and 79%, similar to this finding.<sup>26</sup>

This review showed endoprostheses and allograft-prosthesis showed lowest complications rates. Endoprosthesis reconstruction has several benefits, including greater implant survival, early recovery to function, decreased reported complication rates, and modularity.<sup>2,27</sup> Concerns unique to allografts are also eliminated by using this reconstructive approach, including as non-union, subchondral collapse, allograft fractures, and allograft-host integration.<sup>27,28</sup> Allograft prosthetic composite (APC) has the benefit of restoring the glenohumeral joint, surrounding soft tissues, and the bone stock anatomically. With this reconstructive option, tendons such as the latissimus dorsi, deltoid, rotator cuff, etc., can be attached to the host via host-to-graft soft-tissue attachments.<sup>29</sup> Unlike a prosthesis, the soft-tissue attachments and bony components of the allograft can eventually be entirely absorbed into the host bone and soft tissues. Furthermore, any pre-existing glenohumeral arthrosis can be addressed with this restoration technique. Standard hemiarthroplasty or RTSA implant placement can be employed, allowing for better cost-effectiveness and adaptability. In addition, the patient benefits from early shoulder functionality and instant stability as opposed to an osteoarticular allograft.<sup>27</sup>

## CONCLUSION

Reverse shoulder arthroplasty showed potential for best functional outcomes and no local recurrence occurred during follow-up period. Whereas endoprostheses and allograft-prosthesis showed lowest complications rates. However, further investigation is needed.

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