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REVIEW ARTICLE

Outcomes after revision total elbow arthroplasty: a systematic review

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Background: Although revision arthroplasty surgery is a frequently used treatment for failed total elbow arthroplasty (TEA), published results are conflicting. The aim of this systematic review was to provide an overview of the outcomes of revision TEA surgery.
Methods: A systematic literature search was performed in major databases to find articles relating to outcomes after revision of TEA. Two reviewers independently screened the articles for inclusion, and a third reviewer screened them before final inclusion.
Results: Twenty-one articles containing 532 cases were included. The mean age at revision was 61 years. The mean interval between primary and revision arthroplasty was 77 months, and the average follow-up period was 65 months. Different types of prostheses were included, with 69% of the revision prostheses having linked designs and 31% having unlinked designs. The visual analog scale score, Mayo Elbow Performance Score, Oxford Elbow Score, and range of motion improved significantly after revision surgery. Complications were reported in 232 of 532 cases (44%), leading to reoperations in 22%. After revision with linked prostheses, the Mayo Elbow Performance Score, range of flexion-extension, and pronation improved significantly more than with unlinked designs.
Conclusion: Improved functional outcomes can be expected after revision TEA, but the complication rate remains high. Revision TEA should still be considered a salvage procedure for failed TEA. Linked designs for revision TEA result in better outcomes than unlinked designs in the midterm follow-up.
Level of evidence: Level IV; Systematic Review

Keywords: Revision; total elbow arthroplasty; systematic review; outcome; linked prosthesis; unlinked prosthesis; Coonrad-Morrey

Total elbow arthroplasty (TEA) is an effective and frequently used treatment for patients with severe, debilitating elbow pathology.[4,7] Indications for TEA include rheumatoid arthritis, acute fractures, nonunion, malunion, osteoarthritis, and post-traumatic arthritis.[3,35,38] Despite design developments and the increased frequency of TEA surgery, TEA remains a challenging and technically demanding surgical procedure.[15] Reported complication and failure rates are up to 62% and 90%, respectively.[5,17,20,31,43,46] In comparison with arthroplasty of the hip and knee, the complication and failure rates of TEA are relatively high.[7]

Revision is often indicated when a primary TEA fails. Instability and aseptic loosening of the implant are common

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indications for revision surgery.[1,5,14,25,28,31] Other indications include infection, periprosthetic fracture, and stiffness.[24,43] Owing to the rise in primary TEAs, an increase in revision TEA can be expected.[6,18] The underlying pathology, indication for revision surgery, and prosthetic design could influence the success of revision TEA. Complication rates in revision TEA of up to 30% to 61% have been reported.[11,13,29,44]

Satisfactory results have been reported for both linked and unlinked TEA designs.[16,23,30] Linked designs supply superior stability because of a humeral and ulnar component connection through a sloppy hinge,[9,10,34] whereas unlinked designs use soft-tissue support, bone stock, and bearing surfaces of matching shape for stability.[39]

A large number of articles about the outcomes of the 2 different designs of revision TEA have been published; however, to our knowledge, the outcomes have never been systematically reviewed. The aim of this systematic review was therefore to present an overview of the outcomes of revision TEA and compare the outcomes of linked and unlinked revision TEA designs.

Methods

Study population

Studies containing patients aged 18 years and older who received a revision TEA were included in this review.

Inclusion criteria

The inclusion criteria were a follow-up period of at least 2 years after revision surgery, a minimum of 5 cases per report, and use of a non-customized revision prosthesis.

Search strategies and selection

With the assistance of a clinical librarian, a systematic literature search was performed in PubMed, Embase, and the Cochrane Central Register of Controlled Trials on February 1, 2017. The following terms were used: Arthroplasty[MeSH], Replacement[MeSH], Elbow[MeSH], Revision[MeSH], Total Elbow Replacement[tiab], Revision[tiab]. The search was performed using the filters "Dutch," "English," "German," and "humans."

A total of 1133 articles were found and assessed independently by 2 reviewers (E.J.G. and J.V.) on the basis of their title and abstract. Disagreements were settled by a third reviewer (I.F.K.). A total of 28 articles were considered eligible based on their title and abstract, and the full-text articles on these studies were assessed. After this assessment, 21 articles were included.

Outcome parameters

The outcome parameters used in this review were as follows: visual analog scale (VAS) score for pain (0-10); Mayo Elbow Performance Score (MEPS) for elbow function (0-100); Oxford Elbow Score (OES) for elbow function (0-100); and range-of-motion (ROM) aspects including flexion, extension, pronation, supination, arc of flexion-extension, and arc of pronation-supination. Moreover, numbers of complications and reoperations were included.

Data analysis

A database was made by extracting data from the included articles on follow-up time; sex; age; indication for primary TEA; type of primary prosthesis; survival time of primary prosthesis; interval between primary and revision surgery; indication for revision TEA; type of revision prosthesis; design of revision prosthesis; preoperative and postoperative VAS score at rest and with activity; preoperative and postoperative total MEPS and its individual parameters; preoperative and postoperative total OES and its individual parameters; preoperative and postoperative flexion, extension, range of flexion-extension, pronation, supination, and range of pronation-supination; complications; and reoperations. Fifteen articles included pooled data; the other 6 articles contained data on individual patients. Because of the variability in reporting the types of complications and reoperations, we decided to report the number of complications and reoperations in separate groups. Radiographic evaluation was not included in this review because of the great variability in reporting this outcome. Regarding survival, multiple studies used different endpoints, had a variable follow-up, and were not always reported per case; therefore, we were unable to report on survival in this systematic review. All other outcome parameters (VAS score, MEPS, ROM, OES, complications, and reoperations) were analyzed in the total patient population, as well as in the linked group and unlinked group.

Statistical analysis

VAS score, MEPS, OES, and ROM before and after revision arthroplasty were specified using descriptive statistics. To compare different outcome parameters between the linked and unlinked groups, the paired *t* test and the 2-tailed independent-samples test were used. For all analyses, $P \leq .05$ was considered significant. Analyses were performed using SPSS software (version 21.0; IBM, Armonk, NY, USA).

Results

Patient characteristics

All 21 included reports (Supplementary Table S1) were case series (level IV therapeutic studies).[2,8,11-13,19,21,22,26,27,29,32,33,34,37,38,41-43,45,46] The studies contained a total of 532 patients. The number of patients per study ranged from 11 to 53 cases. The included articles originated from Europe (11 articles), North America (8 articles), and Asia (2 articles) and were published between 1987 and 2017. The mean age of the study population was 61 years, the mean follow-up period after revision surgery was 65 months, and the average time interval between primary TEA and revision TEA was 77 months. The 2 most frequently used prostheses were the Coonrad-Morrey prosthesis (Zimmer, Warsaw, IN, USA) (59%) and Souter-Strathclyde prosthesis (Howmedica, Newbury, UK) (20%). These 2 prostheses accounted for 79% of the revision prostheses. Most of the prostheses in the current

Table I Revision prostheses used in included articles

	n
Linked prosthesis	
Coonrad-Morrey	315
Latitude	18
GSB	12
Pritchard-Walker Mark	12
Schlein	5
Triaxial	5
Total	367 (69%)
Unlinked prosthesis	
Souter-Strathclyde	106
Dogo Onsen Hospital	30
Wadsworth-Mark	9
Capitello-Condylar	8
Mayo	5
London	4
Kudo	3
Total	165 (31%)

GSB, Gschwend-ScheierBähler.

review (69%) were linked (with 31% unlinked). All of the prostheses used and their numbers are shown in Table I.

Outcome parameters

In the total patient group, the VAS score at rest improved from 3.9 preoperatively to 1.5 postoperatively ($P < .001$). With activity, the VAS score improved from 6.3 preoperatively to 3.1 postoperatively ($P < .001$). The total MEPS improved significantly from 46 preoperatively to 80 postoperatively ($P < .001$). The MEPS values for pain, motion, stability, and function all improved significantly after revision surgery ($P < .001$). Flexion improved significantly from 119° to 128°, and the extension deficit improved significantly from 35° to 30°, leading to an increased arc of flexion-extension from 87° to 99° ($P < .001$). Average preoperative pronation and supination were 61°; postoperatively, pronation and supination improved to 66° and 65°, respectively, leading to an increased arc of pronation-supination from 124° to 134° ($P < .001$). Preoperatively, no articles described the OES, and postoperatively, the mean total OES was 65.

In 232 of 532 patients (44%), at least 1 complication occurred. The 3 most common complications were aseptic loosening (22%), transient ulnar and radial nerve symptoms (21%), and periprosthetic fractures (15%). The complications resulted in 128 reoperations in 116 cases (21.8%). Reoperations consisted of a second revision (57%) including a second revision with bone grafting (8%), removal of the prosthesis (22%), cerclage wiring (4%), cement spacer replacement (4%), and débridement with antibiotics (4%). The most common complications and reoperations are shown in Table II.

Outcome measures for the linked and unlinked designs separately are included in Table III. The MEPS, extension deficit, range of flexion-extension, and pronation were better in the linked group and improved significantly more after revision surgery ($P < .001$).

Table II Most common complications and reoperations

	%
Complication	
Aseptic loosening	22
Transient ulnar and radial nerve symptoms	21
Periprosthetic fracture	15
Reoperation	
Second revision	49
Removal of prosthesis	22
Revision with bone grafting	8

The linked group had a complication rate of 46% and reoperation rate of 26%, whereas the unlinked group had a complication rate of 45% and reoperation rate of 20%. The reoperation rate of the unlinked group was lower than that of the linked group ($P < .001$). The indications for revision surgery were comparable in the 2 groups.

Discussion

This systematic review showed that, overall, functional outcomes and patient-reported outcome measures improved after revision elbow arthroplasty. Patients experienced less pain and an increased ROM. However, complication and reoperation rates of 44% and 22%, respectively, were found.

The linked group showed superior improvement in the MEPS and ROM compared with the unlinked group. Although the outcomes for linked prostheses were better, statistical analysis to compare the groups was underpowered because of the small group sizes. Patients who received linked prostheses underwent significantly more reoperations. In general, unlinked designs can only be used in patients with sufficient bone stock and an adequate soft-tissue envelope to provide stability to the operated elbow. This may have introduced a bias and could be responsible for the increased reoperation rate in the linked TEA group.

A trend toward use of linked designs for revision TEA was found, as studies reporting on linked designs were more recent and of better quality than studies reporting on unlinked designs; the need for sufficient bone stock and soft tissue in the unlinked designs, which are often missing in the revision setting, might be the reason for this trend. The linked study group included more than twice as many patients as the unlinked group, and studies reporting on linked designs had a more complete data set, which resulted in higher numbers of parameters that could be studied compared with the reports on unlinked designs. Considering the results of this systematic review and the lower requirement for sufficient bone stock and soft tissue, we suggest that the linked design might be a better option for revision TEA.

Table III Outcome variables in linked and unlinked revision prostheses

Outcome measure	Linked prostheses				Unlinked prostheses			
	Preoperative		Postoperative		Preoperative		Postoperative	
	Mean	n	Mean	n	Mean	n	Mean	n
VAS score								
At rest	3.9	50	1.5	47	NA	0	NA	0
With activity	6.3	50	3.1	47	NA	0	3.1	16
MEPS total	47.0*	179	80.9*	302	42.3	30	76.4	60
OES total	NA	0	64.3	51	NA	0	68.3	10
Flexion	116.4°	157	128.8°	242	123.9°*	101	127.6°	128
Extension deficit	30.6°*	157	24.6°*	236	41.8°	101	41.9°	121
Arc of flexion-extension	89.4°*	241	103.9°*	320	81.6°	111	87.1°	131
Pronation	64.5°*	90	69.2°*	124	58.5°	101	62.7°	107
Supination	57.1°	90	64.0°	121	64.8°*	101	65.9°	101
Arc or pronation-supination	123.4°	174	134.6°	230	125.1°	111	132.9°	131
Complications				169 (46%)				74 (45%)
Reoperations				96 (26%)				34 (20%)*

VAS, visual analog scale; *NA*, not available; *MEPS*, Mayo Elbow Performance Score; *OES*, Oxford Elbow Score.
* Significantly better outcome compared with other group.

In this systematic review, several limitations are recognized. There was substantial variance in reporting results, particularly for radiographic parameters and survival. These outcome measures could therefore not be used in this systematic review. It is important that a more unambiguous way of reporting radiographic outcomes and survival be adopted in future reports on TEA revision. Radiographic outcomes should describe at least the analysis of radiolucency per zone, loosening, fractures, and heterotopic ossification and, preferably, signs of bushing wear. Because of missing information in the articles (not all cases had data on all parameters), the database was incomplete. Consequently, some conclusions have less power than others owing to a small and varying sample size.

Some older studies were included in this systematic review. The designs of TEAs have developed over time, which has resulted in better prostheses and better outcomes. Not only prosthetic designs but also operative techniques have improved, so the inclusion of older studies could potentially have negatively biased the outcomes. Despite the improvements in the designs, a reserved attitude concerning primary TEA is expedient considering the high complication and failure rates in primary arthroplasties, which lead to challenging revision surgical procedures because of a lack of bone stock and soft tissue, resulting in infections, nerve pathology, and other complications. Nowadays, postponing TEAs is possible because of the improvements in the arthroscopic techniques used for débridement in patients with primary or posttraumatic arthritis and the use of partial replacement of the elbow.

The underlying pathology and indication for revision arthroplasty can have a large effect on the outcome.[29,43] Unfortunately, we were unable to differentiate outcomes between different indications for primary and revision surgery as the results were pooled in most of the articles and not complete in others. Further research should focus on the outcomes of revision arthroplasty for different indications. Another suggestion for further research is assessment of the impact of risk factors such as rheumatoid arthritis or diabetes; to make this happen, it is crucial to report these factors as it was not done in most of the articles we found.

Conclusion

Revision TEA leads to improved pain scores, patient-reported outcome measures, and ROM of the elbow. However, a high complication rate of 44% and reoperation rate of 22% were found. Therefore, we still consider revision TEA as a salvage procedure. The indication is an essential factor in the prognosis and success of a revision TEA. Primary TEA is an invasive procedure so, if possible, surgery without joint replacement is preferred. Despite the limited number of patients in the included studies, the outcome parameters of the linked prostheses improved more than those of the unlinked prosthesis designs in the midterm follow-up.

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Supplementary data

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