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The age specific performance of elbow hemiarthroplasty: A systematic review

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Abstract

Background: Compared to total elbow arthroplasty, elbow hemiarthroplasty (EHA) does not have an ulnar component or a hinge/link which eliminates complication risk due to polyethylene wear and ulnar loosening. There are notable gaps in the existing EHA literature. Patient age is often identified as an important determinant when deciding to treat with EHA; however, there is limited age-based evidence. Our systematic review objectives were (a) to compare EHA outcomes between younger and older adults, and (b) to stratify outcomes for EHA by prosthesis.

Methods: In compliance with PRISMA guidelines, databases were searched for EHA studies and 65 years was used to delineate younger and older adults.

Results: Older adults (N = 159) had a significantly higher elbow arc of motion compared to younger adults (N = 121) at a mean follow-up of 51 months. There was a significantly increased risk for a MEPS below 75 in younger compared to older adults. Mean Disabilities of the Arm, Shoulder, and Hand scores and rates of revision/removal were comparable between age groups.

Conclusion: The current findings suggest that although elbow range of motion may be limited in younger adults following EHA, function is satisfactory and comparable to the function in older adults. Additionally, the risk of revision/removal surgery is similar between younger and older adults across short to mid-terms of follow-up.

Keywords

distal humerus fracture, elbow arthritis, elbow hemiarthroplasty, elbow replacement

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Introduction

Elbow hemiarthroplasty (EHA) may be indicated for irreparable distal humerus fracture, rheumatoid or other arthritic conditions, and revision surgery. Compared to total elbow arthroplasty (TEA), EHA does not have an ulnar component or a hinge/link which eliminates complication risk due to polyethylene wear and ulnar loosening. The volume of recent reports indicates an increased interest in EHA.[1–4]

Piggott et al.[4] concluded that EHA provided satisfactory elbow function with low rates of revision in their review of 13 studies and 207 cases. Burden et al.[3] reported superior outcomes in EHA compared to TEA for unreconstructable distal humerus fracture. Complication rates were similarly high across both treatment groups. These findings are consistent with Kwak et al.[5], Nielsen et al.[1], and Wilfred et al.[2] who collectively demonstrated efficacy for EHA as treatment for distal humerus fracture.

There are notable gaps in the existing EHA literature. Patient age is often identified as an important determinant when deciding to treat with EHA.[4–6] Although data for EHA is often reported at a mean patient age around 60 years, there is a broad age distribution across the series from the 3rd to the 7th decade of life.[4] Outcomes are variable across a wide age distribution, thus aggregate data should be reported within more narrow age confines. There are few prosthesis options for EHA. Considerations for prosthesis selection include morphometric design, provisions for repair of adjacent structures, stem fixation, and convertability to TEA. Aggregate data stratified by patient age distribution and prosthesis design will provide to a more complete understanding for EHA.

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Our systematic review objectives were (a) to compare the performance of EHA between younger and older adults, and (b) to stratify outcomes for EHA by prosthesis, describing design features for each. The authors hypothesize that complications may occur more frequently in younger adults than in older adults.

Methods

Query parameters

In compliance with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, PubMed and Google Scholar databases were queried on 24 September 2023, using the following terms: "distal humerus OR elbow AND hemiarthroplasty," "distal humerus AND hemiarthroplasty OR replacement," "elbow AND arthroplasty OR replacement." Relevant systematic reviews and meta-analyses were screened for studies which may not have been captured by the database query. Two authors performed the database search and retrieval, with discrepancies being resolved in conjunction with the senior authors.

Inclusion parameters

Full-text studies were evaluated to determine inclusion based on preliminary and categorical criteria. All included studies were required to meet each of the following preliminary criteria: (a) reporting of adults >18 years of age, (b) treated with EHA for all indications, (c) studies reporting more than four cases with (d) reporting at least one metric between elbow motion, appropriate clinical outcome score or revision surgery. Following preliminary identification, all included studies were required to meet one of the following categorical criteria: (a) reporting of the prosthesis manufacturer or (b) reporting of individual case results for EHA.[7] Studies which did not specify the prosthesis or did not stratify results by the prosthesis were not included. Studies which did not provide individual case results or did not stratify individual case results for EHA were excluded. Follow-up studies from the same institution were excluded due to potential for duplicate cases. Case reports with three or fewer cases were not included.

Data collection

Case variables collected included the following: patient age, patient gender, and term of follow-up. To facilitate data aggregation, the outcome metric requirement was a numeric Mayo Elbow Performance Score (the categorical score did not suffice), or a Disabilities of the Arm, Shoulder, and Hand (DASH) score. The elbow motion requirement was elbow flexion and extension in degrees or an elbow arc of motion in degrees. Revision surgery was defined as a secondary procedure directly related to the EHA. These include revision to TEA for all indications. Secondary procedures to treat ulnar nerve symptoms, stiffness, heterotopic ossification, and infection were not included as revision surgery. Removal surgery was defined as removal of the EHA and did not include removal of other implants such as olecranon osteotomy plates. Complications were defined as removal of implants other than the EHA, and the presence of heterotopic ossification, ulnar wear, ulnar nerve symptoms, and stiffness. To summarize—the outcome variables collected were the following: elbow range of motion, forearm rotation range of motion, MEPS, DASH, complications, and revision surgery.

Quality assessment

The GRADE (grades of recommendation, assessment, development, and evaluation) framework evaluated the quality of evidence across the included studies.[8] Following determination of the phase of investigation, the strength of recommendation was based on the following factors: limitations, inconsistency, imprecision, and publication bias. Serious limitations were identified using a binary scale.

Bias assessment

The Methodological Index for Non-Randomized Studies (MINORS) evaluated the risk of bias across the included studies.[9] This instrument provides a numeric score across eight criteria for non-comparative studies and an additional four criteria for comparative studies. The maximum score for non-comparative studies is 16 and for comparative studies, 24.

Data assessment

The age of 65 years was used to delineate younger and older adults. This was the approximate mean and median of the collected sample. Further, this is a common mean age across the aggregate EHA literature.[2,4,10] The MEPS contains parameters for elbow range of motion, daily activities, stability, and pain. The DASH template evaluates performance difficulty and magnitude of pain during daily activities. A notable parametric difference between these scores is the numeric elbow range of motion in MEPS. The MEPS categorical scoring is the following: excellent is greater than 90, good is 75 to 89, fair is 60 to 74, and poor is lower than 60. Although DASH does not have established score delineations, there is general understanding of the patient's condition across the spectrum of scores. DASH scores were delineated at 30 to represent a change in outcome. Risk ratios were compiled for the age-specific groups. Continuous data were reported as means and standard deviations. Dichotomous data were reported as means. Significance was calculated using two-sample Student's T test and Fisher's exact test.

Results

Query results

Following irrelevant exclusions, 26 full-text studies were screened, of which 21 aligned with the inclusion criteria (Figure 1). The age-specific assessment included 17 studies (N = 280), and the prosthesis-specific assessment included 19 studies (N = 339).

Bias and quality results

The mean MINORS score was 9.2 (range 6, 12) for the 17 non-comparative studies. The mean MINORS score was 18.5 (range 16, 21) for the two comparative studies (Table 1). Within the GRADE framework, the quality of evidence was downgraded due to serious limitations for imprecision regarding sample size and publication bias regarding outcome reporting (Table 2). There was one study with Level I or II evidence.

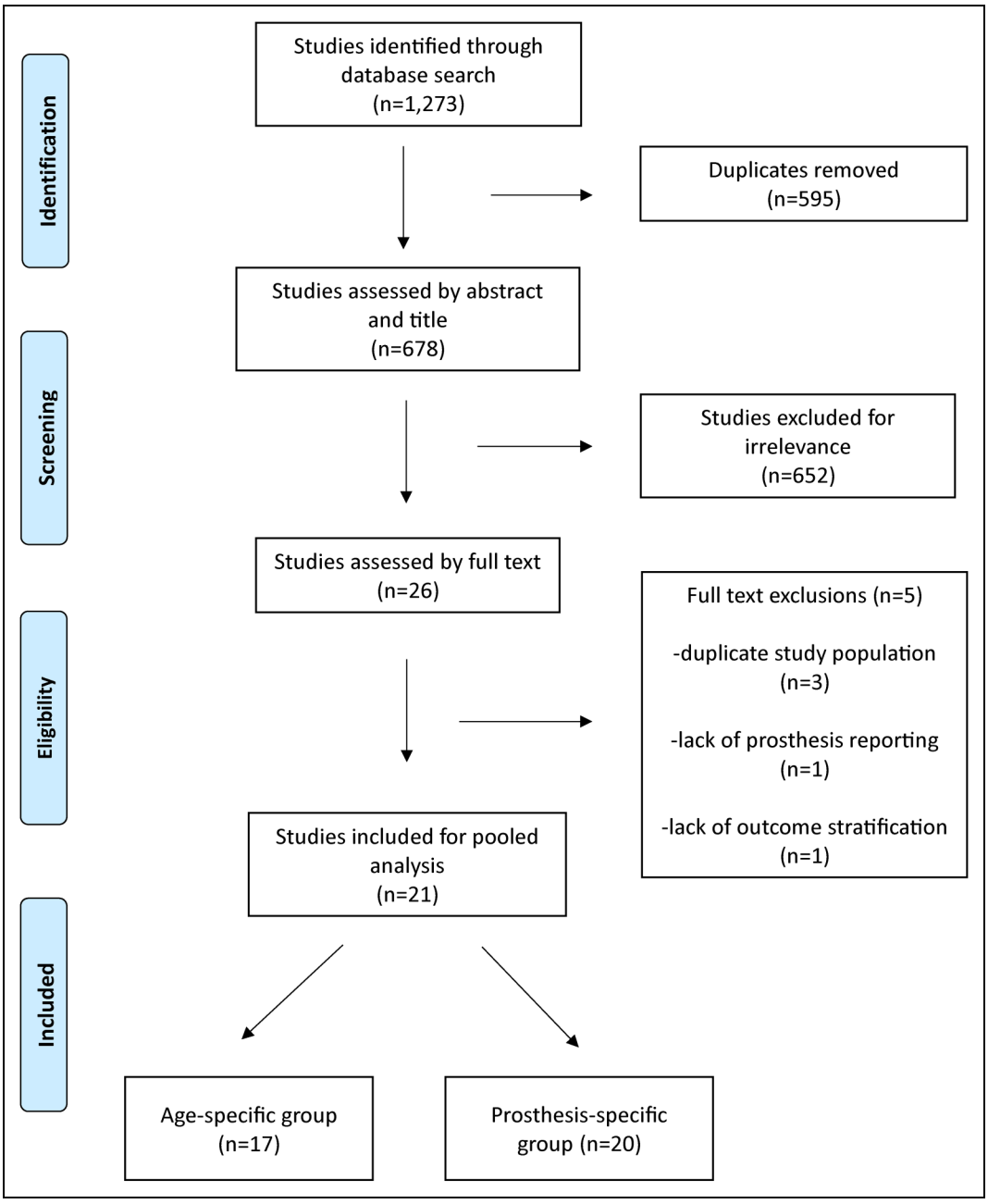

Figure 1. Flowchart summarizing the database search return, assessment, and final selection including specific exclusion criteria.

Table 1. MINORS (methodological index for non-randomized studies) scores for review of elbow hemiarthroplasty. A score of 0 means the criteria was not reported, 1 means the criteria was inadequately reported, and 2 means the criteria was adequately reported.

Criteria	1	2	3	4	5	6	7	8	Total
Non-comparative studies									
Rahme, 2002[11]	2	1	0	2	0	2	1	0	8/16
Parsons, 2005[12]	0	1	0	2	0	2	1	0	6/16
Burkhart, 2011[13]	2	2	0	2	0	2	2	0	10/16
Adolfsson, 2012[14]	2	2	0	2	0	2	2	0	10/16
Argintar, 2012[15]	2	2	0	2	0	2	2	0	10/16
Smith, 2013[16]	2	2	0	2	0	2	1	0	9/16
Hohman, 2014[17]	2	2	0	2	2	2	2	0	12/16
Heijink, 2015[18]	2	2	0	2	0	2	2	0	10/16
Nestorson, 2015[19]	2	2	0	2	0	2	1	0	9/16
Phadnis, 2016[20]	2	0	0	2	0	2	0	0	6/16
Al-Hamdani, 2019[21]	2	2	0	2	0	2	1	0	9/16
Werthel, 2019[22]	2	2	0	2	0	2	1	0	9/16
Rotini, 2020[23]	2	2	0	2	0	2	2	0	10/16
Stephens, 2020[24]	2	2	0	2	0	2	1	0	9/16
Ricon-Recarey, 2021[25]	2	2	0	2	0	2	2	0	10/16
Taylor, 2021[26]	2	2	0	2	0	2	2	0	10/16
Celli, 2022[27]	2	2	0	2	0	2	1	0	9/16
Schultzel, 2022[28]	2	2	0	2	0	2	1	0	9/16
Leung, 2022[29]	2	2	0	2	0	2	2	0	10/16
Mean									9.2

Criteria	1	2	3	4	5	6	7	8	9	10	11	12	Total
Comparative studies													
Dirckx, 2023[30]	2	1	1	1	0	2	1	0	2	2	2	2	16/24
Jonsson, 2023[31]	2	1	2	2	1	2	1	2	2	2	2	2	21/24
Mean													18.5

Case characteristics

Fracture was the most common indication for EHA across the studies where indications were delineated (11/19, 58%).

Age-specific results

Older adults (N = 159) had a significantly ($p < 0.001$) higher elbow arc of motion (110°) compared to younger adults (N = 121, 97°) at a mean follow-up of 51 months (Table 3). There was a significantly increased risk for a MEPS below 75 in younger adults compared to older adults, at age delineations of 60 (RR 2.17, 95% CI 1.24–3.8, $p = 0.006$) and 65 years (RR 2.19, 95% CI 1.22–3.91, $p = 0.008$) (Table 4, Figure 2). DASH scores and rates of complication and revision/removal were comparable between younger adults and older adults.

Table 2. An adapted grading of recommendations assessment, development, and evaluation (GRADE) summarization for review of elbow hemiarthroplasty.

	Limitations		Inconsistency	Indirectness	Imprecision	Publication bias
	I/II LoE[a]	*Risk of bias*	*Outcomes*	*Outcomes*	*Sample size*	*Outcomes*
Included studies	1/21	X	X	X	✓	✓

[a]Studies with I/II level of evidence, ✓ - serious limitations, X - no serious limitations.

Table 3. Case characteristics and outcome comparison for elbow hemiarthroplasty between patients under 65 and over 65 years of age.

Elbow hemiarthroplasty in patients under & over 65 years								
€	*N*	*Age*[a]	*Gender*[a]	*F/U*[a]	*Elbow Flx*[a]	*Elbow Ext*[a]	*Elbow arc*[a]	*Complications*[a]
<65y	121	54 ± 6.5	75%	63 ± 36	123°	25°	97°	39%
>65y	159	76 ± 9.1	84%	39 ± 24	129°	22°	110°	31%
p-value			0.91	**<0.001**	**0.03**	0.98	**<0.001**	0.09

€All values reported as mean and standard deviation, N reported as a sum.
[a]Age in years, gender in female, follow-up in months, elbow flexion, extension, and arc of motion. Bold values represent statistical significance.

Table 4. Clinical outcome comparison for elbow hemiarthroplasty between patients under 65 and over 65 years of age.

Outcome[a]	>65 years	<65 years	Significance
MEPS	87.4 (N = 120)	79.3 (N = 72)	***p* = 0.004**
DASH	19.8 (N = 75)	22.8 (N = 40)	*p* = 0.45
Revision/removal	3.2% (N = 159)	6.6% (N = 121)	*p* = 0.20
Outcome			**Patients older and younger than 65 years**[a]
MEPS below 75			RR 2.19 (95% CI - 1.22, 3.91, ***p* = 0.008**)
DASH score above 30			RR 1.16 (95% CI - 0.65, 2.06, *p* = 0.61)
Implant revision/removal			RR 1.75 (95% CI - 0.62, 4.92, *p* = 0.29)

[a]MEPS–Mayo Elbow Performance Score, DASH—Disabilities of the Arm, Shoulder, and Hand score, 95% CI—confidence interval

Inclusive of both age groups, the most common complications were heterotopic ossification (15.1%), ulnar nerve symptoms (7.4%) and ulnar wear (7.1%), and olecranon plate removal occurred in 4.3% of cases.

Prosthesis-specific results

Results stratified by prosthesis design are shown in Table 5. The largest sample was the Latitude (N = 274) at a mean follow-up of 45.3 months. Rates of revision/removal were 2.9% for Latitude, 8.1% for Kudo (N = 37), and 14.2% for Sorbie (N = 28).

Discussion

EHA was initially described by Mellen and Phalen[32] in 1947, and interest has resurged in recent years. EHA does not have loading restrictions or complications associated

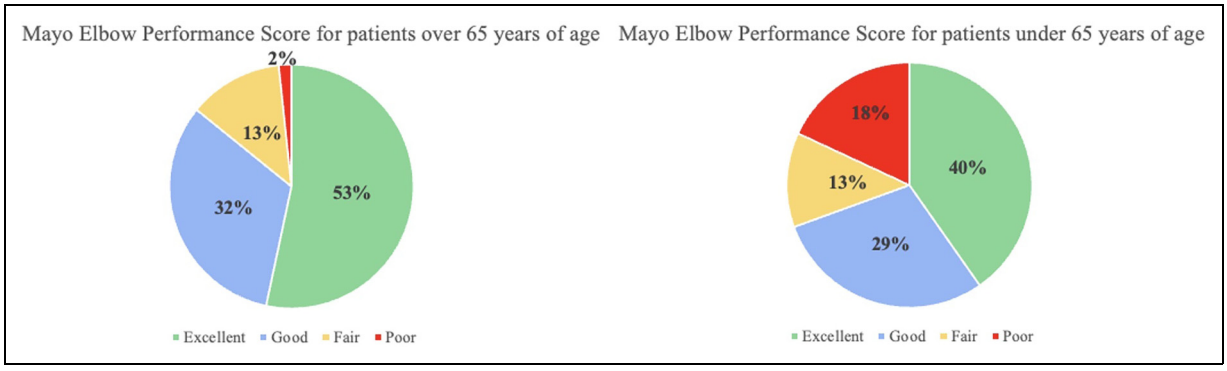

Figure 2. Graphical distribution of categorical results for the Mayo Elbow performance score.

Table 5. Stratification of elbow hemiarthroplasty results by prosthesis design.

€	N	Age	Gender[a]	F/U[a]	Elbow arc of motion[a]	MEPS[a]	DASH[a]	Rev/Rem[a]
Kudo	37	66.6	81%	54 ± 27	105°	90.1 ± 4.9	-	8.1%
Latitude	274	67	83%	45 ± 14	99°	83.7 ± 4.9	18.6 ± 3.4	2.9%
Sorbie	28	56	50%	73 ± 41	99°	77 ± 25	15.9 ± 17	14.2%

€All values reported as means, N reported as a sum.
[a]Gender in female, follow-up in months, elbow flexion and extension, Mayo Elbow Performance Score, Disabilities of the Arm, Shoulder, and Hand score, implant revision or removal.

with polyethylene wear or the articular mechanism that are associated with TEA. Thus, EHA has been described as a more attractive option in younger adults. However, there are concerns for wear of the ulnar articular surface, instability, and the potential for future conversion to TEA. Our results demonstrate satisfactory function in younger adults following EHA despite a significantly shorter arc of elbow motion compared to older adults. Similarly, the rate of revision/removal is comparable between the age groups at short to mid-terms of follow-up.

Reportedly, age is one of the important considerations when evaluating EHA as a treatment option. Older adults with reduced functional requirements represent a majority of the indicated population. The loading restrictions for linked prostheses reduce the utility of TEA for younger adults. Further, ulnar component complications are a concern with TEA. These factors often lead surgeons to treat younger adults with EHA. A notable consideration is the potential for future conversion to TEA which depends on underlying pathology and indication for the index procedure.

Our results demonstrate a two-fold increase in risk of a poor outcome as defined by MEPS in patients under 65 years compared to those over 65 years. Consistent with this finding, patients under 65 years had a significantly lower elbow arc of motion and elbow flexion compared to those over 65 years. However, the mean DASH scores were similar between the age groups. The criteria within the scoring systems may be explanatory. Both metrices evaluate activities of daily living and pain however MEPS contains a point allotment for elbow range of motion. It is well accepted that a 100-degree arc of motion provides satisfactory function.[33] However, younger adults may have greater motion requirements due to the frequency of modern device use. In adults at a mean of 34 years of age, Sardelli et al.[34] reported that functional activities including cell phone use may require an arc-of-motion greater than 100 degrees. The mean elbow arc of motion was 94 degrees in the under 65 group and 104 degrees in the over 65 group. Therefore, it is a reasonable inference that although patients under 65 years have reduced range of elbow motion, their function remains satisfactory. Further, the data indicates that functional outcome of patients under 65 is comparable to those over 65 years. In addition, although the over 65 years group demonstrated a significantly higher MEPS than the under 65 group, this disparity may not meet the established level of clinical importance.[35]

The Kudo prosthesis has a nonanatomic articular morphology and the humeral stem and internal surface of the spool are porous coated for pressfit.[36] The Kudo's nonanatomic articular design may limit the arc of motion and accelerate

joint disease.[14] When converting EHA to an unlinked TEA, exchange of the humeral stem is required.

The Sorbie-Questor is a bone preserving surface arthroplasty with anatomic trochlear morphology.[37] The bony preparation may be described as a resurfacing of the distal humerus. This is intended to offload the prosthesis by transferring load to the surrounding capsuloligamentous structures. Thus, success of this design requires competence of the supporting structures. Theoretically, a more equitable load sharing may reduce the risk of stem loosening. As with the Kudo prosthesis, exchange of the humeral stem is required when converting EHA to an unlinked TEA. Compared to the older Kudo, the morphology of the Sorbie articulation has a more anatomic morphology. Across the limited sample, the data indicates an increased risk of revision for the Sorbie prosthesis at a mean follow-up of 73 months.

The Latitude hemiarthroplasty requires comparatively more bone resection to accommodate the anatomically designed articular spool. A cannulated screw attaches the spool to the stem which allows transarticular fixation of medial and lateral structures. This is especially useful in fracture cases to facilitate ligament repair and further stabilize the construct with attachment of condylar fragments.[38] The Sorbie and Kudo do not provide this option thus supplemental wires/plates/screws are required. When converting to a linked or unlinked TEA, the EHA spool is replaced with a spool that articulates with the ulnar stem. Notably, the humeral stem accommodates the EHA and TEA spools, thus it is retained during the conversion.

The most recent EHA review by Piggott et al.[4] reported rates of reoperation and revision of 17% and 3%, respectively, across an age range of 44 to 79 years and follow-up range of 11 to 82 months. One of the included studies had a mean patient age under 50 years and the authors advised caution in this population due to the limited evidence of the age-specific performance of EHA. Burden et al.[3] performed a comparative review of EHA (N = 112) and TEA (N = 538) in patients over 65 years. The authors reported a lower rate of revision and superior clinical outcomes for EHA at a mean age of 76 years and mean follow-up of 41 months. Taylor et al.[6] compiled one of the largest analyses on elbow replacement for distal humerus fracture, comparing 293 EHA cases to 613 TEA cases. In patients under 65 years of age, there was a lower rate of revision for EHA (10%) compared to TEA (18%). Further, the authors concluded that EHA was a viable treatment option in patients older than 75 years as revision rates were comparable between EHA and TEA. Our results are consistent with those of Taylor et al.[6] demonstrating that age may not be a significant risk factor for revision of EHA, at short to mid-terms of follow-up.

We acknowledge limitations of the current work beginning with those inherent to systematic reviews. Outcome data may be impacted by measurement technique, practitioner methods, and outcome definitions. There are inconsistent case definitions in the EHA literature regarding common complications following elbow trauma such as heterotopic ossification and stiffness. The contribution of the prosthesis in the presence of these complications is controversial and ultimately unknown. The recent increase in reporting for EHA provides improved understanding and implies that EHA may be increasing in utilization, but long-term results remain infrequent. Comparative analysis between prostheses is limited due to disparity in aggregate sample sizes. The relative infrequency of EHA allows individual case reporting, but the aggregate sample sizes are low relative to other upper extremity arthroplasties. The age of 65 years was chosen as it was the approximate mean age in former EHA reports, and this is often the age used to delineate younger and older adults. However, reported outcomes for EHA are likely to be impacted by increasing or decreasing this age delineation. Although age is a primary consideration when evaluating treatment with EHA, other case variables which certainly contribute are difficult to amalgamate. It is presumed that the anatomic spool was used for EHA but due to infrequent reporting, we were unable to compile this data. There are established delineations of categorical scoring for MEPS; however, no such standard exists for DASH scores. We chose a DASH score of 30 to delineate results due to anecdotal experience and discussion with those who are experienced in collecting this metric. Due to infrequency of reporting, we were unable to analyze both MEPS and DASH for individual patients which would provide a clearer illustration of the derived conclusion. Further, the literature did not allow stratification of results based on indications for EHA. Fracture was the most commonly reported indication; however, the case definitions for fracture varied and the inclusion of other indications into data synthesis was an additional limiter. Our results did not include studies that were deemed a risk for duplicate sampling. These studies have been collectively reported in prior reviews and would increase the current sample size; however, the understood risk of sampling bias was prioritized. Finally, the current conclusions were derived from data collected at short to mid-terms of follow-up. These analyses may not be generalizable for longer terms of follow-up.

Conclusion

The current findings suggest that although elbow range of motion may be limited in younger adults following EHA, function is satisfactory and comparable to the function in older adults. Additionally, the risk of revision/removal surgery is similar between younger and older adults across short to mid-terms of follow-up. The majority of the EHA literature reports on the Latitude prosthesis which demonstrates low rates of revision and advantageous characteristics.

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