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Surgical approaches for total elbow arthroplasties using data from the Dutch Arthroplasty Register

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Background: Total elbow arthroplasty (TEA) is a relatively infrequently performed procedure. Therefore, nationwide databases help to provide more insight into factors that might influence implant survival, for example, the surgical approach used. Using data from the Dutch Arthroplasty Register, we aimed to reveal whether high-volume centers use different approaches than low-volume centers and whether the approach is implant specific.

Methods: Using data from 2014 to 2017, we compared the surgical approaches used for high- vs. low-volume centers, as well as for the 2 most frequently used types of TEA, by use of χ^2 tests.

Results: We analyzed 276 procedures. In 2016 and 2017, when posterior approaches were further specified, the triceps-on approach was used most frequently in the high-volume center (27 of 42 procedures, 64%) and the triceps-flap approach was used most often in the low-volume centers (48 of 84 procedures, 57%) ($P < .001$). For the 2 most frequently used types of TEA, the Coonrad-Morrey and Latitude EV arthroplasties, the surgical approaches did not differ. When the high-volume center was compared with the low-volume centers, implant choice differed, with the Coonrad-Morrey arthroplasty being most often used in the high-volume center and the Latitude EV arthroplasty, in the low-volume centers.

Conclusion: The posterior triceps-flap approach was the most frequently used surgical approach in primary TEA in the Netherlands, yet the triceps-on approach was used more often in the high-volume center. The surgical approaches did not differ between the 2 most frequently used types of TEA in the Netherlands.

Level of Evidence: Epidemiology Study Using Large Database Analysis

Keywords: Total elbow arthroplasty; models; surgical approach; demographics; register data; national joint registry; volume

A multitude of approaches to the elbow joint have been described in the literature, each with its own advantages and disadvantages, usually concerning the triceps brachii muscle and tendon.[3,9,12] Triceps handling is of importance during rehabilitation; when the continuity of the muscle

Institutional review board approval was not required for this epidemiology study.

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fibers and tendon is impaired, elbow extension strength has to be moderated to prevent a triceps tendon rupture. Studies comparing surgical approaches generally are single-center studies, covering a particular case series and comparing the outcomes with those of other approaches or narrative reviews.[1,11]

Possible surgical approaches include a triceps-split posterior approach, in which the triceps brachii muscle is incised and split longitudinally for intra-articular access.[1,9,11] A triceps-flap approach entails the creation of a triceps tendon flap that will be reflected during surgery and, afterward, will undergo refixation to the triceps fascia.[1,8,9,11] A triceps-on approach keeps the triceps muscle intact, which means a less direct intra-articular view yet less triceps muscle fiber interruption.[1,9,11] An olecranon osteotomy with flipping over of the complete triceps keeps the muscle fibers intact as well yet is associated with nonunion of the osteotomy.[1,11] Other approaches are possible as well, such as the medial epicondyle osteotomy and the triceps split-and-snip approach.[3,12]

As total elbow arthroplasty (TEA) is a relatively infrequently performed procedure, nationwide databases could help to provide more data than single-center studies. In New Zealand, Sweden, and the UK, the surgical approach for TEAs has already been reported. However, no analyses on the use of different approaches have been published yet. The New Zealand Joint Registry is the sole register to report data on approaches in its yearly report.[10,13-15] These approaches are categorized as posterior, lateral, or medial.[10] Unfortunately, no further analysis of these data has been performed regarding TEA model or differences between high- and low-volume centers.

The aim of this study was to provide an overview of the surgical approaches used for primary TEA in the Netherlands, whether these approaches differ between high- and low-volume centers, and whether the approach is implant specific using population-based Dutch Arthroplasty Register data.

Materials and methods

The Dutch Arthroplasty Register (Landelijke Registratie Orthopedische Implantaten [LROI]) prospectively collects data on primary and revision arthroplasties. In 2014, the registration of TEA was initiated with almost complete coverage of Dutch hospitals. The LROI contains patient characteristics such as age, sex, American Society of Anesthesiologists score, previous surgery on the affected joint, body mass index, smoking habit, and diagnosis. Furthermore, procedure and prosthesis characteristics such as the date of surgery, hospital, surgical approach, prosthesis, fixation technique, linkage type, ulnar nerve handling, and use of bone grafts are collected in the LROI.[4] For this cross-sectional study, we included all primary TEAs performed in the period from 2014 until 2017.

The surgical approach was categorized as lateral, posterior, posterior triceps flap, posterior triceps on, posterior triceps split, olecranon osteotomy, or other. In 2014 and 2015, only the "posterior" option was possible. This category was specified as posterior triceps on, posterior triceps flap, and posterior triceps split starting in 2016. Therefore, a representative comparison of approaches is only possible for surgical procedures performed since 2016. High-volume centers were defined as centers with 10 or more TEA procedures performed per year in the period from 2014 to 2017.[6]

Demographic data and the number of surgical approaches were described using descriptive statistics. The approaches and types of TEAs used in high- vs. low-volume centers were compared using the χ^2 test. Because of a multitude of TEA models, we analyzed the 2 most commonly used prostheses. Analyses were performed using IBM SPSS Statistics software for Windows (version 24; IBM, Armonk, NY, USA).

Results

In the Dutch Arthroplasty Register, 276 primary TEAs were registered from 2014 until 2017 (72 in 2014, 78 in 2015, 67 in 2016, and 59 in 2017). The rate of data completeness increased from 69% in 2014 to 91% in 2017.[4] Overall, the mean age at surgery was 65 years (range, 22-91 years) and 75% of patients were women. The main diagnoses for surgery were rheumatoid arthritis (36%), secondary osteoarthritis (27%), and primary osteoarthritis (20%) of the elbow joint (Table I).

A posterior approach of any kind was used in the large majority of procedures (262 of 276, 95%). When posterior approaches were further specified since 2016, the triceps flap was the approach most often used in the Netherlands (61 of 126 procedures, 48%), followed by the triceps-on approach (47 of 126 procedures, 37%) and triceps-split approach (12 of 126 procedures, 10%) (Table II).

The median number of procedures reported per center was 8 in the 4 years registered, with a range of 0 to 23 procedures per center per year and a range of 1 to 83 procedures during the entire period (Fig. 1). Of the 22 reporting hospitals that performed TEA, 1 was defined as a high-volume center ($\geq$10 TEAs per year). One hospital performed 10 or more procedures annually in 2014 and 2015 but reported performing fewer procedures in the subsequent 2 years (2016 and 2017) and was therefore not considered a current high-volume center in further analyses. In the high-volume center, a total of 83 TEAs were performed, predominantly using the triceps-flap approach (45 of 83 procedures, 55%). The low-volume centers also predominantly used the triceps-flap approach (86 of 193 procedures, 45%) (Table III). When we performed the χ^2 test using the data from 2016 and 2017, the triceps-on approach was used most frequently in the high-volume center (27 of 42 procedures, 64%) and the triceps-flap approach was used most often in the low-volume centers (48 of 84 procedures, 57%) ($P < .001$).

Assessment of the 2 types of TEA most often used in 2016 and 2017 and their surgical approach resulted in a comparison between the Coonrad-Morrey (Zimmer

Table I Demographic characteristics of all patients who underwent TEA between 2014 and 2017 in the Netherlands

	2014 (n = 72)	2015 (n = 78)	2016 (n = 67)	2017 (n = 59)	Overall (N = 276)
Age, mean (range), yr	64 (22-90)	63 (28-85)	69 (42-85)	66 (33-91)	65 (22-91)
% female patients	74	69	73	85	75
ASA score, n (%)					
I	8 (11)	10 (13)	7 (10)	4 (7)	29 (11)
II	49 (68)	52 (67)	42 (61)	30 (51)	171 (62)
III or IV	15 (21)	16 (20)	19 (29)	25 (42)	75 (27)
Smoking, n (%)	15 (21)	29 (26)	7 (11)	3 (5)	45 (16)
BMI, mean (SD)	29 (5.5)	27 (4.7)	26 (5.7)	27 (5.0)	27 (5.2)
Previous surgery, n (%)					
Yes	45 (62)	38 (49)	30 (45)	26 (44)	139 (50)
Osteosynthesis	14 (19)	12 (15)	13 (19)	12 (20)	51 (19)
Osteosynthesis removal	4 (6)	7 (9)	9 (13)	8 (14)	28 (10)
Lateral arthrotomy	24 (33)	18 (23)	15 (22)	11 (19)	68 (25)
Medial arthrotomy	5 (7)	4 (5)	5 (8)	3 (5)	17 (6)
Posterior arthrotomy	16 (22)	9 (12)	8 (12)	9 (15)	42 (15)
Ulnar decompression	—	—	5 (8)	7 (12)	12 (4)
Ulnar transposition	—	—	—	2 (3)	2 (1)
Arthroscopy	3 (4)	3 (4)	3 (5)	1 (2)	10 (4)
Arthrodesis	1 (1)	—	—	—	1 (1)
Other	7 (10)	11 (14)	10 (15)	4 (7)	32 (12)
Diagnosis, n (%)					
Rheumatoid arthritis	27 (38)	29 (37)	25 (37)	18 (31)	99 (36)
Primary osteoarthritis	13 (18)	21 (27)	10 (15)	11 (19)	55 (20)
Secondary osteoarthritis	20 (28)	18 (23)	18 (27)	19 (32)	75 (27)
Fracture	3 (4)	7 (9)	9 (13)	9 (15)	28 (10)
Hemophilic arthropathy	1 (1)	—	—	—	1 (1)
Inflammatory arthritis	1 (1)	—	1 (2)	—	2 (1)
Osteonecrosis	2 (3)	1 (1)	—	—	3 (1)
Metastasis or tumor	1 (1)	—	1 (2)	1 (2)	3 (1)
Other	2 (3)	2 (3)	2 (3)	1 (2)	10 (4)

TEA, total elbow arthroplasty; *ASA*, American Society of Anesthesiologists; *BMI*, body mass index; *SD*, standard deviation.

Company, Warsaw, IN, USA) TEA (n = 50) and Latitude EV (Wright Medical, Memphis, TN, USA) TEA (n = 36). Their posterior approaches did not differ significantly (P = .691). Ulnar nerve handling with decompression was used in 76% of procedures in 2016 and 61% of procedures in 2017.

Discussion

On the basis of population-based registry data from the LROI, the posterior approaches that require triceps handling were used most frequently (95%) for TEA. When further specified since 2016, the triceps flap was the approach most often used in the Netherlands, followed by the triceps-on approach and triceps-split approach. The triceps-on approach was used most frequently in the high-volume center, and the triceps-flap approach was used most often in the low-volume centers.

As the different approaches have their specific advantages and disadvantages, rehabilitation differs accordingly.[9] The most often used triceps-flap approach requires moderation of elbow extension during rehabilitation as the triceps muscle has been interrupted to prevent the serious complication of a triceps rupture.[2,8] A triceps-on approach does not necessarily need moderation of the elbow extension force, which may be beneficial in gaining range of motion earlier in the rehabilitation process.[2,5,12] However, the surgical exposure for the triceps-on approach is different from that for the triceps-flap and triceps-split techniques as direct vision into the intramedullary canal of the ulna is more difficult; this could be the reason the triceps-on approach is used more often in centers with more experience.[1,11]

This study is the first using the Dutch Arthroplasty Register data on TEA and shows a difference in surgical approaches between high- and low-volume centers. As the specification of posterior elbow approaches has been in use since 2016, a more valid comparison between centers was possible. Nevertheless, the triceps-on technique was used most frequently in 2016 and 2017 (27 of 50 cases in the high-volume center and 20 of 78 in the low-volume

Table II Procedure and prosthesis characteristics

	2014 (n = 72), n (%)	2015 (n = 78), n (%)	2016 (n = 67), n (%)	2017 (n = 59), n (%)	Overall (N = 276), n (%)
Approach					
Lateral (LCL)	—	—	—	2 (3)	2 (1)
Posterior	25 (35)	24 (31)	—	—	49 (18)
Posterior triceps flap	37 (51)	33 (42)	31 (46)	30 (51)	131 (48)
Posterior triceps on	6 (8)	11 (14)	27 (40)	20 (34)	64 (23)
Posterior triceps split	2 (3)	4 (5)	6 (9)	6 (10)	18 (7)
Olecranon osteotomy	—	1 (1)	—	—	1 (1)
Other	2 (3)	5 (6)	3 (5)	1 (2)	11 (4)
Model prosthesis					
Linked					
Discovery (Biomet, Warsaw, IN, USA)	4 (6)	6 (8)	1 (2)	6 (10)	17 (6)
Latitude (Tornier, Montbonnot Saint Ismier, France)	13 (18)	—	—	—	13 (5)
Latitude EV (Wright Medical, Memphis, TN, USA)	10 (14)	32 (41)	27 (40)	11 (19)	84 (30)
NES (Implant Cast, Buxtehude, Germany)	3 (4)	9 (12)	7 (11)	5 (9)	24 (9)
Coonrad-Morrey	21 (29)	23 (30)	27 (40)	25 (42)	96 (35)
Unlinked					
iBP (Biomet, Warsaw, IN, USA)	10 (14)	2 (3)	—	—	12 (4)
K Elbow (Stryker, Limerick, Ireland)	—	2 (3)	3 (5)	3 (5)	8 (3)
Latitude	1 (1)	—	—	—	1 (1)
Latitude EV	2 (3)	2 (3)	—	—	4 (1)
Other or unknown	8 (11)	2 (3)	2 (3)	9 (15)	21 (8)
Radial head implant					
Latitude	9 (13)	11 (14)	11 (16)	5 (9)	31 (11)
Ulnar nerve handling					
Decompression	2 (3)	9 (12)	51 (76)	36 (61)	98 (36)
Transposition	3 (4)	6 (8)	14 (21)	19 (32)	42 (15)
Unknown	67 (93)	63 (80)	3 (4)	4 (7)	136 (49)

LCL, lateral collateral ligament.

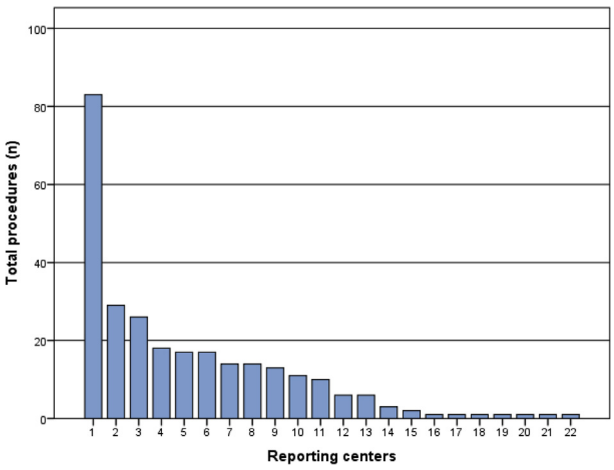

Figure 1 Number of primary total elbow arthroplasties per hospital as reported to Dutch Arthroplasty Register between 2014 and 2017.

centers). This finding could be explained by implementation of newer surgical techniques with the advantage of keeping the triceps muscle and tendon intact and, therefore, theoretically fewer restrictions on the elbow extension force.[2,9] No comparison to other national registry outcomes is possible as no data considering the approaches are available in the literature or national registries' reports.

Data from the Scottish arthroplasty register have shown fewer complications when 10 or more TEAs are performed per center on a yearly basis.[6] Regarding the median number of 2 primary TEAs implanted per center per year in the Netherlands, centralization of surgery could possibly provide better patient care. Of note, revision arthroplasties are not taken into consideration in the current data on primary TEAs; therefore, centers now labeled as "low volume" could have more experience with TEA care. Hence, further research based on Dutch TEA data should be performed to examine the effect of surgeon volume on outcomes in the Netherlands.

Table III Comparison of approaches and implant models as registered in Dutch Arthroplasty Register between high- and low-volume centers

	High volume (1 hospital) (n = 83)	Low volume (21 hospitals) (n = 193)	*P* value
Approaches in 2014-2017			<.001
Lateral (LCL)	—	2	
Posterior	—	49	
Posterior triceps-flap	45	86	
Posterior triceps-on	35	29	
Posterior triceps-split	2	16	
Olecranon osteotomy	1	—	
Other	—	11	
Posterior approaches in 2016-2017			<.001
Posterior TC flap	13*	48*	
Posterior TC on	27*	20*	
Posterior TC split	2*	10*	
Type of total elbow prosthesis			<.001
Linked			
Discovery	—	17	
Latitude	—	13	
Latitude EV	—*	80*	
NES	—	24	
Coonrad-Morrey	80*	16*	
Unlinked			
iBP	—	12	
K Elbow	—	8	
Latitude	—	1	
Latitude EV	—	4	
Other or unknown	3	18	

LCL, lateral collateral ligament.
* $P < .001$ for comparison between high- and low-volume centers.

Data gathering and data completeness are essential for meaningful arthroplasty research. Dutch orthopedic surgeons and their teams are requested to register their arthroplasty procedures in the LROI. The LROI has already reached a completeness rate of 91% for 2017 when cross-checked with hospital data, which is high for a relatively new national database.[7] Presumably, when more feedback is provided to the registering surgeons by use of personal feedback using a personal digital ''dashboard,'' it is hoped that essentially complete hip and knee arthroplasty registration will be reached.[16]

In this study, only primary procedures were selected for homogeneity of the study population. We excluded revision procedures such as conversion of a radial head arthroplasty to a TEA, which might give the orthopedic surgeon additional experience in TEAs. However, in revision TEA, the approach used for the primary surgical procedure may play a confounding role, especially when complications have occurred, such as triceps tendon insufficiency. We have therefore chosen to analyze primary surgery only because probably fewer unreported surgical considerations are of importance than in revision surgery.

The number of procedures per surgeon cannot yet be retrieved from the LROI. Therefore, we categorized hospitals based on their TEA volume instead of using the TEA volume per surgeon, which may produce bias as the surgeon volume remains undetermined. A future analysis using the surgeons' data could provide more information; such an analysis should be performed with caution as 2 surgeons can cooperate during 1 surgical procedure. In addition, implementation of functional follow-up scores would be of great scientific value to monitor the results after TEA.

Conclusion

The posterior triceps-flap approach was the most frequently used surgical approach in primary TEA in the Netherlands based on population-based registry data. The surgical approaches did not differ between the 2 most frequently used types of TEA in the Netherlands, the Coonrad-Morrey and Latitude EV arthroplasties. The type of TEA differed between the high- and low-volume hospitals in the Netherlands, with the Coonrad-Morrey TEA being most often used in the high-volume hospital and the Latitude EV TEA, in the low-volume hospitals. In addition, the triceps-on approach was used more often in the high-volume center.

Disclaimer

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