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Description of a new surgical approach for elbow arthroplasty: Selective Triceps-On Medial Paraolecranon (STOMP) approach

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A R T I C L E I N F O

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Level of evidence: Level IV; Case Series; Treatment Study

Background: Surgical approaches for total elbow arthroplasty (TEA) are broadly divided into two groups; “triceps-off” and “triceps-on” approaches. Traditional “triceps-off” approaches provide excellent visualization for TEA; however, they carry a risk of triceps failure and require triceps protecting rehabilitation protocols. Triceps-on approaches have the advantage of preservation of triceps function yet present technical challenges for access to and preparation of the bony surfaces of the proximal ulna and radius. We present here the operative technique, indications, and initial outcomes of a novel Selective Triceps-On Medial Paraolecranon (STOMP) approach for TEA, which allows both preservation of the triceps function and excellent exposure to the proximal ulna with minimal risk to the ulnar nerve.
Methods: A two center, retrospective cohort study of all patients undergoing primary TEA, hemiarthroplasty, or revision elbow arthroplasties using the STOMP approach in the practice of the senior authors between 2010 and 2020 were reviewed. Patient data, including admission demographics and diagnoses were collated. Outcome measures were collected from patient charts.
Results: A total of 37 elbow arthroplasties in 35 patients were performed with the STOMP approach during the reviewed period, of which 27 patients (77%) were female. Thirty-two arthroplasties were primary cases (86%), and 5 (14%) were revision cases. The main indications leading to elbow arthroplasty was rheumatoid arthritis (n = 18, 49%) followed by primary or secondary elbow osteoarthritis (n = 9, 24%) and distal humeral fracture (n = 7, 19%). There were 7 postoperative complications (19%). Five patients (14%) developed elbow stiffness, one patient a postoperative olecranon fracture (n = 1, 3%) and one patient had an ulnar nerve injury with incomplete resolution but that did not warrant surgical treatment (n = 1, 3%). A reoperation was required in 3 patients (9%).
Conclusion: The STOMP approach is a safe approach for elbow arthroplasty surgery. It does not detach the triceps and we believe it offers improved exposure and safety compared to other triceps-on techniques. Furthermore, this approach allows excellent surgical access to the coronoid, olecranon, and ulnar canal with low midterm complications.

Excellent clinical outcomes can be achieved with total elbow arthroplasty (TEA).[14,21] Historically the most common indication for a TEA was elbow rheumatoid arthritis (RA).[9] However, improved medical treatment of RA along with expanded indications for TEA have resulted in a shift to acute trauma and post traumatic arthritis as the most common indications for TEA. Over the last few decades there has been a steady increase in the number of TEA implantations.[6,28]

Surgical approaches for TEA have been constantly evolving. They can be divided into the following two groups depending on how they manage the triceps tendon insertion: (1) “Triceps-off” and (2) “Triceps-on”. Triceps-off approaches are the traditional technique of access to the elbow for TEA. They have been used because they offer excellent exposure allowing good access to joint surfaces and the humeral and ulnar canals. Complications with triceps failure have led to development of triceps-on approaches. Surgeons who advocate for triceps-on approaches argue that they allow for almost

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immediate active motion of the elbow in rehabilitation. They minimize risk of triceps failure and maintain better extension strength.[2,19,24] In addition, clinical outcomes might be superior.[5,23] However, triceps-on techniques can cause difficulty with the visualization during the ulnar component insertion leading to potentially higher component malalignment.[12] Component malalignment increase edge loading[4] of polyethylene bearings possibly leading to implant loosening and the need for revision surgery.

The aim of this body of work is to present the operative technique, indications, and initial outcomes of a novel Selective Triceps-On Medial Paraolecranon (STOMP) approach for elbow arthroplasty, which allows preservation of the triceps function yet offers excellent exposure with minimal risk to the ulnar nerve.

Methods

Patient population, study design, and outcome collection

A retrospective case series review was conducted. Institutional ethics approval was obtained. All patients undergoing either a hemiarthroplasty or a primary or revision TEA using a STOMP approach by either of the two senior authors (T.G., B.A.) between 2010 and 2020 were included in this study. Patient data including admission demographics, diagnosis and operative details were collated. Outcome measures included range of motion (ROM) and complications. Specifically, complications with triceps insufficiency, wound healing, elbow stiffness (ROM arc of less than a 100° as per Morrey et al),[17] and ulnar nerve symptoms were collected from patient charts.

Statistical analysis

Descriptive statistics was used to summarize the findings. Categorical variables were summarized with percentages and continuous variables with means and standard deviations. The data analyses were conducted using Microsoft Excel (version 16.48; Microsoft, Redmond, WA, USA).

Surgical technique

After adequate anaesthesia, the patient is positioned either in the supine or the semilateral decubitus position depending on the surgeon's preference. A regular or sterile tourniquet can be used. With the tourniquet inflated to 250 mmHg, an approximately 14-cm posterior incision is used biased either to medial or lateral side of the olecranon. The incision is made down to the triceps fascia. Medial and lateral flaps are elevated directly off fascia to just beyond the levels of the epicondyles.

The ulnar nerve is identified proximally on the medial aspect of the triceps. Next, the nerve is neurolysed with preservation of vasculature and motor branches from 10 cm proximal to 5 cm distal to the medial epicondyle. The nerve must be mobilized adequately to allow sharp or electrocautery dissection of the flexor-pronator mass from the ulna, bed of ulnar nerve and medial epicondyle without risk of injury to the nerve.

There are the following two windows to access the elbow joint: medial and lateral.

Medial window

The medial window requires dissection of the flexor pronator mass and the medial ¼ of triceps tendon from the proximal ulna, olecranon, and medial epicondyle in one continuous sheet (Fig. 1). A facial rim is left on the ulna border to allow repair. Approximately, the medial quarter of the triceps tendon is taken off the olecranon with the flexor pronator mass. This strip of tendon allows for a good repair of the medial head of the triceps back to the rest of the intact triceps tendon with a side-to-side repair. The section of triceps removed is an important step to allow access to the ulnar canal for reaming and component placement and positioning. Proximal extension is limited by branches of the radial nerve to medial head of the triceps. In our experience the triceps tendon split can extend approximately 10 cm to give excellent exposure while not placing the ulnar nerve or radial nerve at risk.[8,15] For more extensive exposure of the humerus (often required in revision surgery) the radial nerve should first be identified in the lateral.

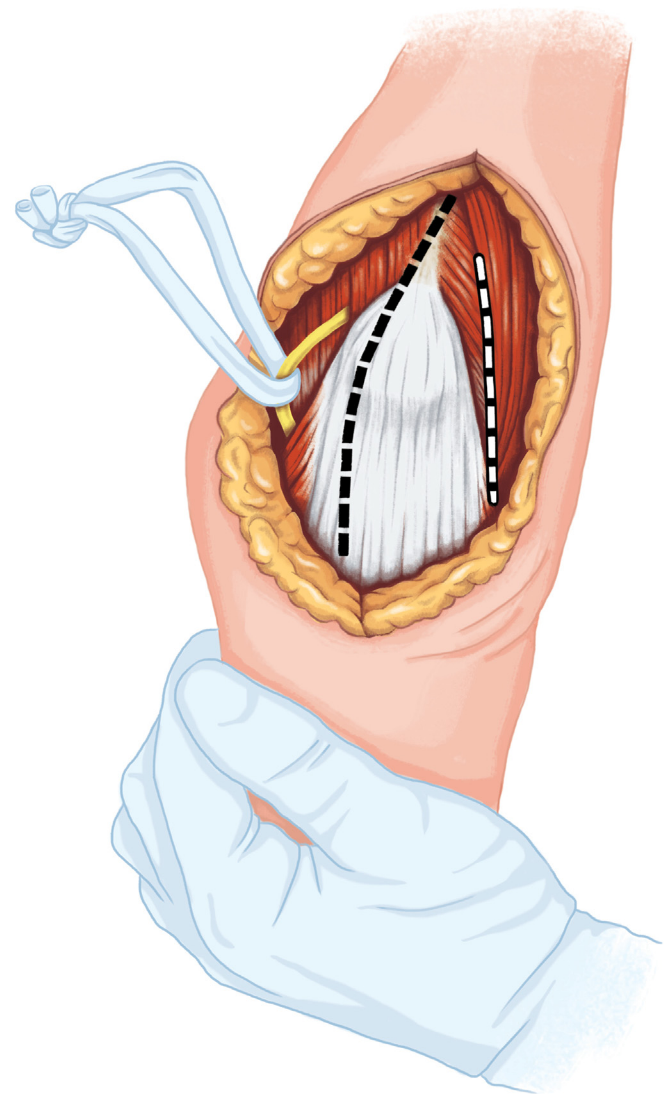

Figure 1 Medial and lateral windows of the STOMP approach. The black dotted line represents the medial window and the white dotted line the lateral window of the surgical approach. *STOMP*, Selective Triceps-On Medial Paraolecranon.

Dissection of the flexor/pronator mass from the ulna can extend as far anteriorly as the brachialis insertion. Dissection of the flexor pronator mass off from the medial epicondyle in conjunction with medial collateral ligament release allows access to the anterior joint and capsule. Posteriorly, the triceps muscle can be dissected away from the distal humerus to the posterolateral aspect of the distal humerus. The medial dissection not only allows excellent access to the ulnar canal for reaming and broaching of the ulnar component but also superior access to the coronoid and sigmoid notch (Fig. 2). This is particularly important when using a prosthesis which

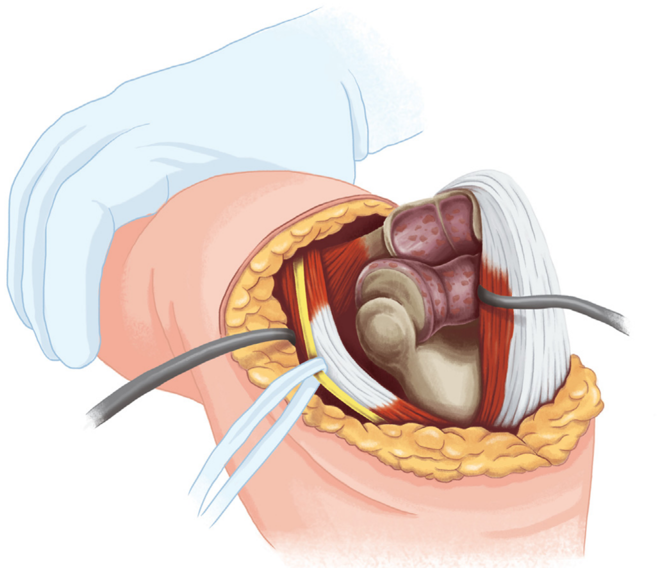

Figure 2 Visualization from the medial window of the STOMP approach. Supination of the forearm will assist to enhance the view from the ulna. *STOMP*, Selective Triceps-On Medial Paraolecranon.

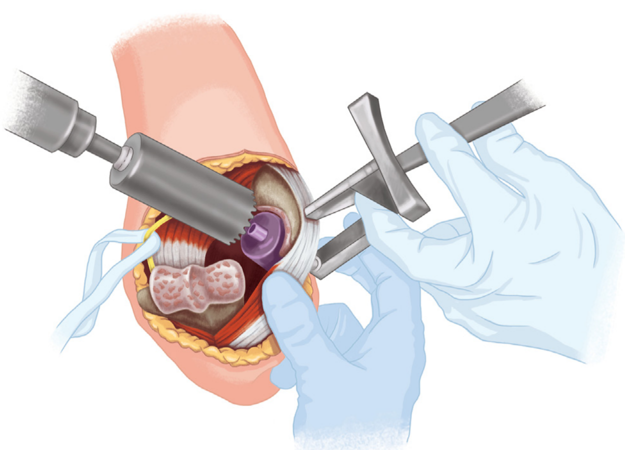

Figure 3 This illustration shows the distinct advantage of the STOMP approach when working medially with the bell saw. The dissection moves the flexor pronator mass anteriorly along with the ulnar nerve decreasing the risk of injury to the nerve during the sigmoid notch preparation. *STOMP*, Selective Triceps-On Medial Paraolecranon.

requires preparation of the sigmoid notch (eg, the Latitude EV uses a bell saw). The distinct advantage of this approach is that the dissection moves the flexor pronator mass anteriorly along with the ulnar nerve as a single unit, decreasing the extent of nerve neurolysis and handling throughout the procedure. This moves the ulnar nerve away from the bone of the proximal ulna and decreases risk of injury to the nerve during preparation of the sigmoid notch for prosthetic placement. In addition, this avoids the difficulties that the ulnar nerve flexor carpi ulnaris branches might pose to the nerve mobilization as the flexor carpi ulnaris is being lifted off with this continuous sheet (Fig. 3).

Lateral window

The lateral window is developed using the Kocher interval between the anconeus and extensor carpi ulnaris distal to the lateral epicondyle, and between the triceps and extensor origin proximal to the lateral epicondyle (Fig. 4). Sharp dissection with knife or cautery exposes the lateral aspect of the distal humerus after releasing the extensor supinator mass along with the lateral collateral ligament origin and capsule allowing dislocation of the elbow either medially or laterally. Access to the radial head is through the anconeus/extensor carpi ulnaris interval. The advantage of including the anconeus with the triceps includes preservation of nerve supply to the anconeus and an enhanced soft tissue sleeve on the ulna. Access to the radial nerve, if required is achieved through extension of this interval proximally.[7]

At the end of the procedure, the ulnar nerve can either be anteriorly transposed subcutaneously or brought back with the flexor pronator mass to its original location without transposition. The advantage of transposing the nerve is that it allows mobilization of the nerve away from the medial epicondyle. Transposition also allows for minimal nerve dissection in any possible future revision surgery.

Further details of the procedure are shown in the STOMP surgical technique Supplementary Video S1.

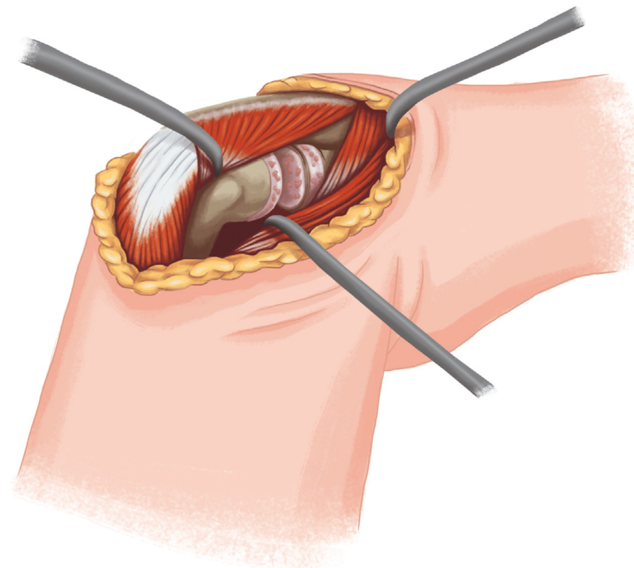

Figure 4 Visualization achieved through the lateral window of the STOMP approach. *STOMP*, Selective Triceps-On Medial Paraolecranon.

Results

Cohort characteristics

A total of 37 elbow arthroplasties were performed in 35 patients during the reviewed period (2010-2020) using the STOMP approach. Most patients were females (n = 27, 77%), in their sixties. From the 37 elbow arthroplasties, the majority were TEAs (n = 35, 95%). The remaining 2 cases (5%) were hemiarthroplasties. In our cohort, this surgical approach was used mainly for primary cases (n = 32, 86%) and the rest were revision arthroplasties (n = 5, 14%). The leading indications for elbow arthroplasty were: 1) RA (n = 18, 49%); 2) primary or secondary osteoarthritis (n = 9, 24%); 3) distal humeral fractures (n = 7, 19%); and 4) component failure (n = 3, 8%). The mean follow-up was 7.9 months (standard deviation ± 4.8 months). Further details regarding the cohort of patients can be seen in Table I.

Range of motion

ROM data were available for 26 out of 37 (70%) elbow arthroplasties at the 6-week follow-up. The same proportion (70%) had

Table I
Cohort characteristics.

Characteristic	TEA cohort = 35 patients (37 elbows)
Age mean (SD)	64 (10.2)
Range [min-max]	57 [34-91]
Sex n (%)	
Males	8 (22.9)
Females	27 (77.1)
Preoperative diagnosis n (%)	
Rheumatoid arthritis	18 (48.6)
Distal humeral fracture	7 (18.9)
Primary or secondary OA	9 (24.3)
Failed component	3 (8.1)
Type of elbow replacement n (%)	
Total elbow replacement	35 (94.6)
Hemiarthroplasty	2 (5.4)
Type of surgery n (%)	
Primary	32 (86.4)
Revision	5 (13.5)
Components used n (%)	
Tornier	31 (83.7)
Coonrad-Morrey	4 (10.8)
Missing	2 (5.4)
Adverse events n (%)	7 (18.9)
Ulnar nerve injury	1 (2.7)
Stiffness	5 (13.5)
Periprosthetic fracture	1 (2.7)

SD, standard deviation; *TEA*, total elbow arthroplasty; *OA*, osteoarthritis.

Table II
Elbow range of motion (ROM) in follow-up visits.

Movement	6 weeks F/U	Last F/U visit
Flexion° mean ± SD [min-max]	108.8°± 24.6° [40°-145°]	121.8°± 31.4° [40°-155°]
Extension° mean ± SD [min-max]	27°± 15.2° [0°-70°]	20.2°± 14.6° [0°-70°]
Pronation° mean ± SD [min-max]	67.3°± 23.4° [0°-80°]	73.3°± 19.3° [0°-90°]
Supination° mean ± SD [min-max]	64.2° ± 28.6 [0°-90°]	71.3°± 25.4° [0°-90°]

SD, standard deviation.

ROM data recorded at their final follow-up visit. Seven patients had ROM measurements available only at the 6-week follow-up, while another seven had measurements solely at their final follow-up. Mean flexion, extension and pronation and supination ROM values can be found in Table II.

Complications and reoperations

From the 37 elbow arthroplasties, there were seven complications leading to a 19% complication rate. Three patients required reoperations because of their complication (9%).

The most common complication in our cohort was elbow stiffness (n = 5, 14%). One patient (3%) suffered a periprosthetic fracture (olecranon fracture), one patient had ulnar nerve dysfunction (3%). No patients suffered wound healing problems.

From the five patients with elbow stiffness, one required a surgical capsular release. This patient preoperatively had an almost ankylosed elbow, with an arc of motion of 20° and no forearm rotation. Postoperatively, the patient developed an heterotopic ossification and despite improving to a flexion-extension arc of 75° still had no forearm rotation and required an osteocapsular arthroplasty. A second patient had a stiffness associated with a concomitant adhesive capsulitis of the ipsilateral shoulder. The patient was managed conservatively and was satisfied with the final ROM (flexion 60°, extension 30°, pronation 80° and supination 80°) at the 1-year follow-up visit and declined any further operative intervention. The other three patients had elbow stiffness as per Morrey et al definition of functional ROM but did not require/ask for any additional treatment.

The patient who suffered an ulnar nerve dysfunction had both motor and sensory involvement. At final follow-up (1 year), this patient had only mild symptoms that did not warrant surgical intervention.

One patient suffered a postoperative periprosthetic olecranon fracture but had a stable ulnar component. This patient had poor quality bone secondary to RA. Preoperatively, their elbow was chronically dislocated. However, postoperatively the bone eroded through the skin and the patient required two surgical irrigation and débridements and a subsequent triceps advancement flap to achieve coverage. The complication was resolved at the final follow-up and the authors feel this was not directly related to the STOMP approach but is included in the analysis.

Discussion

The aim of any surgical exposure for TEA is to allow for adequate access to the distal humerus and proximal ulna to achieve correct implant positioning, while decreasing the complications related to the approach. Malrotation of the humeral component or malalignment in varus/valgus can abnormally load both unlinked and linked TEAs and affect the moment arms of the muscles across the elbow, changing the kinematics of the implant.[4,22] Furthermore, poorly aligned components can be a predictor of early loosening and the need for subsequent revision surgery.[3] There is also some emerging evidence that implant positioning can also affect pain, extension strength and functional outcomes.[13]

Surgical approaches to the elbow for TEA have been a topic of discussion among surgeons for years. Numerous techniques have been described and as previously mentioned, divided into 'triceps-on' and 'triceps-off 'approaches. Triceps-off surgical approaches involve either partial or complete detachment of the extensor mechanism from its insertion into the ulna. The triceps-off group can be further subdivided into triceps turndown, triceps elevating or triceps splitting.[2] Restoration of the triceps mechanism after its detachment is essential to prevent extensor weakness and allow patients rehabilitation. The traditional approach of detaching it from bone has shown higher incidence of muscle weakness and triceps failure.[2,5] Triceps-off techniques require protected mobilization with gravity assisted extension and avoidance of active extension for 6-8 weeks (requiring a slower rehabilitation progression to protect the triceps repair with the subsequent concerns on stiffness development).[19] Furthermore there is literature supporting significantly better ROM arcs and less flexion contracture in patients undergoing triceps-on approaches.[5,24]

Alternatively, posterior access to the elbow may also be achieved by a transolecranon approach via an olecranon osteotomy.[16,20] Olecranon osteotomies have worked well for fracture exposure and fixation and for hemiarthroplasty of the elbow. However, an olecranon osteotomy does have its limitations when performing elbow arthroplasties and is rarely used in this setting as a result of the compromise of the ulna for component fixation, requirement for fixation and potential for olecranon nonunion.[2,19]

Triceps-on approaches, also known as triceps preserving, sparing or triceps retaining, maintain the triceps insertion in continuity with the olecranon. As a group, their main advantage is to allow for earlier patient rehabilitation as the extensor mechanism does not need to be protected during the postoperative period.[2,27] On the other side, triceps-on approaches have been criticized due to a more challenging proximal ulna exposure compared with triceps-off approaches. There is evidence of increased ulnar component misplacement. The positioning of the ulnar implant tends to be placed slightly into flexion and pronation when compared to the optimal targeted angle when doing triceps-on approach.[2,18] Nevertheless, it is uncertain how this will impact the implant survival.

We describe a novel triceps-on surgical approach termed the selective triceps-on medial paraolecranon (STOMP) approach for elbow arthroplasty. The senior authors (T.G; B.A) developed this surgical approach after encountering difficulties using the lateral paraolecranon approach described by Studer et al,[24] both due to concerns for the safety of the ulnar nerve (especially when using the bell saw in the Latitude TEA system), but also due to dissatisfaction with the achieved exposure to the proximal ulna. In our described approach, access to the medial face of the sigmoid notch is greatly facilitated while simultaneously moving the ulnar nerve well out of harms way. Overall, the complications in our cohort showed a 19% rate which is on the lower end of what has been previously published.[25,26] However, our study lacks long-term follow-up; therefore, complications such as radiographic loosening, periprosthetic fractures, or delay periprosthetic infection might still occur and thus underreported.

The incidence of presenting ulnar nerve neuropathy was 3% within our cohort which is similar to what has been published in the literature.[25] This supports the hypothesis that it is a safe technique to handling the medial soft tissue sleeve and the ulnar nerve within it which might be a concern for other surgeons who would like to adopt this technique within their clinical practice. Previous studies have shown that ulnar nerve complication reporting after elbow arthroplasty lacks standardization and is likely underreported. Ulnar nerve dysfunction can be variable in presentation, severity and chronicity, may be present prior to the surgical intervention and may recover completely.[26] Ulnar paresthesia is common.[23] There have been reports in the literature of an incidence approaching 40% but tend to resolve within 6 weeks.[1,10,11] In our cohort study we report only one patient with ulnar nerve symptoms that were present up to 1 year but that did not require further intervention.[25] No symptoms of transient ulnar nerve dysfunction were documented. However, given the retrospective nature of this review, the accuracy of this finding cannot be verified. Nonetheless, it is the senior authors' impression that transient ulnar nerve paresthesia has nearly disappeared with this approach compared to their experience when other approaches were utilized in the past.

A distinct advantage of the STOMP approach is ulnar nerve safety if revision surgery required. It is our practice to use a nonabsorbable suture for closure of the medial and lateral intervals. Subsequent surgery requires following the same marked interval without risk of harm to the ulnar nerve once it is transposed. It is our practice, however, to identify the ulnar nerve without completely dissecting it to ensure it has not moved posteriorly from its transposed position. This dissection proceeds only to identification and verification of location of the ulnar nerve. Once shown to be anterior to the medial epicondyle further dissection and potential injury to the nerve is avoided and the medial window can proceed without fear of injury to the nerve.

There are very few limitations of this approach. However, medially the proximal extent of the window is partially limited by branches of the radial nerve to the medial head of triceps muscle that when present, can be found around 8-to-10 cms proximal to the medial epicondyle.[8] Furthermore, the proximal extent of the lateral window is also limited by the radial nerve as it exits the lateral intermuscular septum. In revision surgery requiring extensive exposure of the humerus the Gerwin et al approach is used to identify and preserve the radial nerve.[7] Access to the humerus is made through the lateral window.

In the senior authors' impression, the STOMP approach seemed to be successful in giving better ulnar side exposure and potentially facilitating ulnar component placement. Furthermore, the medial window facilitated preparation of the sigmoid notch without fear of injury to the ulnar nerve. However, cadaveric studies are needed to objectively measure and compare the ulnar exposure with other triceps-on approaches. The technique allows complete closure of the myofascial layers to create a barrier between the implants and the subcutaneous space. This avoids communication between implants and subcutaneous space in the event of hematoma or seroma formation in the subcutaneous layer.

Limitations

Due to the retrospective nature of this study, we had some limitations, particularly in data collection for ROM, as only 70% of the cases had follow-up ROM measurements at the last follow-up. In addition, the length of follow-up is suboptimal. Another limitation inherent to retrospective reviews is that the data is dependent on information recorded in the notes. As previously mentioned, transient ulnar nerve dysfunction is probably under-reported in most retrospective series. Lastly, the retrospective nature of this study impaired the ability to collect additional functional outcomes which would have been desirable. Nevertheless, we believe that this cohort allow the authors to share the short to midterms outcomes and safety profile of a new surgical approach with certain advantages compared to the already described.

Future studies assessing the components positioning and long-term patient's follow-up to assess implants survival rate with this novel approach are needed. In addition, including patient-reported outcomes measures, and prospectively collecting data on ulnar nerve permanent and transient dysfunction and objective triceps strength measurements is warranted.

Conclusion

We describe a new triceps-on surgical approach named STOMP. The STOMP surgical approach is a safe alternative for elbow arthroplasty surgery. This approach has some potential advantages when compared with triceps-off approaches and for revision surgeries; it is a safe alternative to other described triceps-on approaches. Furthermore, it allows excellent exposure of the coronoid and sigmoid notch on the medial side with very low short to midterm complications. Further studies with long-term follow-up assessing components positioning and survival, patient-reported outcomes and complications rate are needed to better determine its safety profile in elbow replacement surgery.

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Supplementary Data

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