Anconeus sparing minimally invasive approach for lateral ulnar collateral ligament reconstruction using a triceps tendon autograft is an effective and safe treatment for chronic posterolateral instability of the elbow

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Abstract:

BACKGROUND: Surgical treatment helps restore stability to the elbow in patients with posterolateral rotatory instability (PLRI). The anconeus muscle is one of the most important active stabilizers against PLRI. A minimally invasive anconeus sparing approach for lateral ulnar collateral ligament (LUCL) reconstruction using a triceps tendon autograft has been previously described. The purpose of this study was to evaluate the outcome of this intervention and identify risk factors that influenced the clinical and patient reported outcomes.

METHODS: Sixty-one patients with chronic PLRI and no previous elbow surgery that underwent surgical reconstruction of the LUCL using a triceps tendon autograft in a minimally invasive anconeus sparing approach during 2012 and 2018 were assessed. Outcome measures included a clinical examination and the Oxford Elbow Score (OES) and the Mayo Elbow Performance Score (MEPS) questionnaires. Subjective patient outcomes were evaluated with the Visual analogue scale (VAS) for pain and the Subjective Elbow Value (SEV). Integrity of the common extensor tendons and centering of the radial head were assessed preoperatively on standardized MRIs.

RESULTS: The mean age of patients was 51±12 years with a mean follow up of 53±xx months (range 20-76). Clinical examination after surgery showed no clinical signs of instability in 98% of the patients ($P<.001$) and a non-significant improvement in range of motion. OES, MEPS and VAS averaged 40 out of 48 points (SD: 10), 92 out of 100 (SD:12), and 1 (SD:2), respectively, all corresponding with good or excellent outcomes. The SEV was 88% indicating very high satisfaction with the surgery. Only one patient had to undergo revision surgery due to pain and there were no reported postoperative complications in this cohort. Superior clinical results were observed in patients without radius subluxation in the preoperative MRI.

CONCLUSIONS: The anconeus sparing minimally invasive technique for posterolateral stabilization of the elbow using a triceps tendon autograft is an effective and safe treatment for chronic posterolateral instability of the elbow with substantial improvements in elbow function and pain relief with very low rate of re-instability.

LEVEL OF EVIDENCE: Therapeutic Level IV.

KEYWORDS: posterolateral elbow instability; PLRI; lateral ulnar collateral ligament; anconeus muscle, elbow

Introduction:

Lateral elbow pain is a very common pathology, with various causes. One of these is an elbow instability with different presentations ranging from an acute instability onset after trauma, to a chronic instability over time (1). The posterolateral rotatory elbow instability (PLRI) was first described by O´Driscoll et al in 1991 (2) and it is the most common chronic elbow instability (3).

There are several reasons for chronic PLRI; amongst them are failed conservative therapy or failed ligament healing after elbow dislocation (2, 4), repetitive trauma or overuse to the lateral ulnar collateral ligament (LUCL) (5), a cubitus varus deformity, which leads to a chronic overload of the LUCL (6), a chronic tendinosis of the common extensor tendon origin may also lead to insufficiency of the underlying LUCL (7) and iatrogenic insufficiency due to failed treatment of extensor tendinosis, either due to multiple cortisone injections or surgical damage of the LUCL (8-10).

One of the key aspects of managing and successfully treating PLRI is understanding the biomechanics of how the passive and dynamic stabilators work in the elbow joint (11). The LUCL is the main stabilizer against varus stress and PLRI (12). Any insufficiency of the LUCL complex often results in symptomatic posterolateral ulnoradial joint (sub)luxation and may compromise activities of daily living, specific sport activities, and manual labor requiring varus and posterolateral stability of the elbow. The majority of patients do not present with a subjective instability, but with lateral elbow pain, weakness and/or clicking (13).

The anconeus muscle forms a functional unity with the lateral collateral ligament (14). It is one of the dynamic stabilizers of the elbow and protects against posterolateral rotatory instability. Different anatomic and electromyographic studies have identified the anconeus as a potential posterolateral stabilizer of the elbow (4, 14, 15). In vitro studies have shown that tensioning of the anconeus even restores the stability of a posterolateral unstable elbow (16).

While conservative treatment is of limited use, mainly reserved for very mild cases or patients for whom surgery is contraindicated, PLRI can be successfully treated with surgery and shows generally very good outcomes (17). Several LUCL reconstruction surgical techniques using various grafts have been repeatedly shown to be able to restore posterolateral elbow stability (9, 18-23) and improve patient symptoms. All of these techniques have in common a lateral approach to the elbow, with release of the common extensor tendon and the anconeus. We previously described a new minimally invasive anconeus sparing technique for LUCL reconstruction in patients with PLRI (24).

The aim of this study is to provide the first long term clinical and functional outcomes in patients that underwent this recently developed anconeus sparing minimally invasive surgical approach to LUCL reconstruction, and to identify factors that can help predict the outcome of this surgery. Our hypothesis is that this new surgical approach to LUCL reconstruction is a safe and effective treatment for PLRI.

Materials and Methods:

Study design

This is a retrospective case series study to assess the long term functional and clinical outcomes after minimal invasive anconeus sparing surgery to repair posterolateral instability of the elbow. The study received ethics committee approval (19-1595-101), and written informed consent was obtained from all study participants.

Patients that had the anconeus sparing LUCL reconstruction surgery between January 2012 and December 2018 were identified and asked to participate in the study. Patients were invited to an in person follow up, and when not possible the functional outcomes and patient satisfaction scores were obtained either per video call, email or telephone.

Participants

The primary inclusion criteria were follow-up of a minimum of 24 months after surgery, age between 18 and 80 years and having had the anconeus sparing LUCL reconstruction with an ipsilateral triceps graft during 2012 and 2018 due to PLRI. Patients with previous surgery of the investigated elbow were excluded.

The initial diagnosis of PLRI was done based on clinical history and positive clinical instability tests and confirmed arthroscopically (25). A standardized preoperative magnetic resonance images (MRIs) in full extension was obtained for all participants. Before the intervention, all patients had undergone conservative treatment with oral nonsteroidal anti-inflammatory drugs and the majority completed a supervised rehabilitation program for at least six months. Persisting pain and/or subjectively unacceptable dysfunction despite this treatment were indications for LUCL reconstruction.

Clinical Assessment:

The clinical evaluation before surgery and at follow up included a standardized physical examination including assessment of range of motion (ROM), clinical tests for instability; the Stand-Up Test, the Push-Up Test (26), the Laptop-Test, the pincer grip (27), the lateral pivot-shift apprehension test (3) and global evaluation of the varus/valgus stability of the elbow in 0°, 30° and 60° of flexion in pronation. During follow up, patient and clinician reported outcomes were evaluated using the Oxford Elbow Score (OES) (28) and the Mayo Elbow Performance Score (MEPS) (29), which have shown to have high specificity and responsiveness to asses patients after elbow surgery (30). Subjective scores included the Visual Analog Scale (VAS) for pain and the Subjective Elbow Value (SEV). The SEV was determined by asking the patient to subjectively rate the operated elbow in comparison with a completely normal elbow, which was considered to have an SEV of 100% (31). The SEV has been reported to be an easy and reliable tool for evaluating elbow-related pathologies (32, 33).

In the pre-operative MRIs, radius pathology (including fractures and joint congruity), tears to the common extensors and tears to the lateral collateral ligament (LCL) were assessed. The influence of the following factors in patient outcomes was evaluated for the full cohort; previous cortisone injections, history of elbow trauma, the duration of symptoms, the degree of common extensor tendon defect, the presence of LCL tears and radius pathology in MRIs.

Surgery and rehabilitation protocol:

All surgeries were performed by the same expert elbow surgeon (S.G.) according to a previously described technique (24). Patients are placed in a lateral decubitus position with the upper arm resting on an adjustable arm holder. Before ligament reconstruction, a posterior drawer test is performed under arthroscopic visualization as well as a diagnostic arthroscopy in order to confirm instability. A Wissinger rod is used to do a “drive-through” test through the radiocapitellar joint to confirm the PLRI and evaluate its severity (34).

Using a dorsal incision, the triceps fascia is identified and a 0.7 x 5-6 cm graft from the ulnar aspect of the triceps tendon is harvested. Using an additional incision at the ulnar side the anconeus muscle is identified, preserved and retracted posteriorly (Figure 1). An incision at the humeral side allows the release of the common extensor origin to expose the lateral epicondyle and the upper quarter of the capitulum. A 3.2 mm monocortical drillhole is then made in the proximal ulna distal to the radial neck at approximately a 60° angle to the long axis of the ulna. The triceps graft is fixed using a 2,6 x 12 mm subcortical flip button (BicepsButton, Arthrex GmbH, Munich, Germany) at the ulnar side. After having identified the isometric point at the capitellum which lies close to the center of curvature of the capitulum the length adjusted graft is then shuttled following the upper border of the anconeus superficial to the capsule but underneath the extensor tendons proximally and fixed at the isometric point of the capitellum using an interference screw (5.5 mm PEEK SwiveLock, Arthrex GmbH, Munich, Germany) (Figure 2 and 3). The common extensors are brought to their origin, repaired and the wounds are closed in layers.

After surgery, the elbow is immobilized using a splint in 90° for 14 days. An elbow brace with free flexion and an extension block at 30° with no pronation or supination is used for another two weeks afterwards. Starting the 5^{th} week after surgery, the extension and pronation/supination block is removed, allowing full range of motion of the elbow in the brace for another week. After five weeks, the splint was discontinued and active range-of-motion were initiated with isometric strengthening exercises of the elbow. Heavy load bearing and varus loading exercises were not allowed until three months after surgery and were continued until six to nine months postoperatively.

Statistics

All calculations were performed with SPSS Statistics (Version 26, Property IBM Corp., NY, USA). Due to non-normal distribution of the data, non-parametric tests were used. The Wilcoxon Signed Rank test was used to assess changes in ROM pre- and post-surgery. Clinical instability was compared using the McNemar's Test. Outcome variables were assessed either with the Mann-Whitney U Test for nominal variables or the Spearman´s rank correlation for continuous variables. A Kruskal-Wallis-Test was used for categorical variables with more than one category. For continuous variables the statistical means, range and standard deviations are presented while frequencies and percentages are used for categorial variables. For all tests a significance level of $p < 0.05$ was used.

Results:

Participants

81 patients met the inclusion criteria and 61 were enrolled in the study. Of the study cohort 9 were lost to follow up; 1 missed their appointment and 8 did not complete the survey. The final analysis included data from 52 patients (figure 4). The questionnaire of one patient had to many missing items to be able to be accurately scored for all functional scores. Forty-one patients had an in person clinical follow up.

The mean age was 51± 12 years (range, 20-76 years) and patients were examined for the purpose of this study at a mean of 53 ± 14 months (range, 27-86 months). Over half the patients (53%) had received steroid injections previous to the surgery and a history of trauma as the probable cause of PLRI was identified in 18 of the patients 35% of patients. Demographic and main participant data is summarized in Table 1.

Clinical Data

Before surgery 43 of the 52 (86%) patients showed positive clinical instability. The remaining 14% were diagnosed intraoperatively. No patient on this cohort showed clinical instability at 6 months follow up. At final follow-up (> 2 years) only one of the forty-one assessed patients had a positive clinical instability test ($p < .001$). Range of motion showed a slight but non-significant improvement (Table 2). No patient had an extension deficit of more than 10° at follow up. The biggest range of motion gain was seen on a patient going from 40 degrees of extension deficit to no extension deficit. The biggest reduction in ROM was 15 degrees in a patient that was previously able to over-extend the elbow.

Complications

Out of the 52 patients only one patient required revision surgery due to continued pain and subjective feeling of instability. The postoperative MRI done 4 years after the initial surgery showed a partial tear of the CE as well as ossification process along the CE and the radial epicondyles. The elbow was centered and the LUCL transplanted was intact. The revision surgery was done 55 months after the original LUCL reconstruction and included bursectomy of the fossa oleocrani, partial synovectomy and superficial debridement of the LUCL.

MRI and intraoperative findings

In preoperative MRI at least a partial tear of the common extensor tendons, tears to the lateral collateral ligaments and/or postero-lateral subluxation of the radial head were present in all patients.
Forty-six patients (88%) reported a partial or complete tear of the common extensor (CE), with only two MRIs showing an intact CE. Tears to the lateral collateral ligament (LCL) were confirmed in 45% of patients with a further 31% having a suspected tear. The radius was not centered in 43% of patients. The level of instability was assessed arthroscopically, with the vast majority (94%) having moderate to severe instability (levels 2 to 4).

Patient reported outcomes results

The Oxford Elbow Score at final follow up was 40.4 ± 10.5 (range 13 to 48) of a maximum of 48 points with higher values indicating less severity. The mean MEPS was 91.7 ± 12.0 (range 60-100), with 86% of patients having good or excellent scores with no scores rated poor. Scores below 60 points are considered poor; between 60 and 74 points, fair; between 75 and 89 points, good and 90 or above is considered an excellent score (35). The mean VAS score was 1.2 ± 2 (range 0-8), and the SEV mean was 87.9% ± 16.5 (range 30% to 100%).

There was no significant difference in clinical outcomes or patient reported outcomes scores between patients that received cortisone injections previous to the surgery or those with an etiology history of elbow trauma. There was also no statistically significant correlation between scores and age, duration of symptoms or follow-up time. CE findings in the MRI showed no difference in scores. A Kruskal-Wallis test was carried out to compare score values in patients with no LCL Tear, suspected tear and confirmed tear. There was a significant difference ($p < 0.05$) between the mean ranks of at least one pair of groups. Wilcoxon signed rank pairwise tests were carried out for the three pairs of groups. A statistical difference ($p < 0.05$, adjusted using the Bonferroni correction) was found between the groups suspected tear and no tear. There were no significant differences between the other pairs of groups. A subluxation of the radius was significantly correlated with worse outcomes, especially pain (Table 3).

Discussion

The most important findings of this study show that a minimally invasive and anconeus sparing approach to LUCL reconstruction has great outcomes that effectively restore stability of the elbow joint in 97.6% of patients with a very low complication rate. To our knowledge, this is the first study showing the mid-term to long-term results and clinical outcomes of this anconeus sparing minimal invasive surgical approach to LUCL reconstruction to treat PLRI.

Schoch et al. published in 2022 one of the biggest LUCL reconstruction studies involving 178 patients with a mean follow up of 91 months. They also used an autologous triceps tendon graft (36) and showed excellent results with a final MEPS of 91.3 and a mean OES of 46.5. However, they reported a slight but significant loss of range of motion as well as a re-instability rate of 8.5% (37). The mean age of the patients involved was 31 years. Furthermore, a recent systematic review by Fares et al. involving 11 papers and 148 patients showed a re-instability rate of 10% and a 2.7% revision rate (38) with a mean MEPS of 89.7. The average age in the metanalysis was 34 years. Additionally, an earlier systematic review by Anakwenze et al showed similar results with an average MEPS of 91.0 and a recurrent instability rate in 8% of patients. The analysis included 130 patients from 8 different studies with a mean age of 38.1 years (39).

While the clinician and patient reported outcomes in our study are very similar to other surgical techniques for LUCL reconstruction, this approach showed a much lower rate of post-surgery elbow instability with only 2.4% of patients having instability at follow up. In our study the patient that required a revision surgery had a history of elbow trauma, a finding consistent with a previous study by Geyer et al, who found instability rates of 6.5% confined to the group of patients with trauma as the etiology of PLRI (40).

Previous studies have found a correlation between younger age and improved outcomes (41). The cohort from this study is older when compared to the majority of PLRI treatment studies, with a mean age of 52 years. We expected to see worse outcomes correlating with increased age but there was no correlation between age and clinical outcomes in our study, indicating that this new approach is effective regardless of age.

In addition the clinical examination done in this study support that this surgery successfully stabilizes the elbow without compromising range of motion, avoiding one of the most common residual features of elbow surgery (42). None of the patients had more than 10 degrees of extension deficit, compared to seven patients having 10 or more degrees of extension deficit before the surgery. While the increase in range of motion was not statistically significant for the cohort, at the individual level the vast majority of patients showed very clinically relevant improvements and there were no patient complaints regarding range of motion.

The lower re-instability and complication rate supports the hypothesis and biomechanical data that the anconeus plays a very important role on the elbow stabilization process. Biomechanical data has shown, that the humeral most isometric insertion point of the LUCL is between the 3:00 and 4:30 o´clock position on a circle on the lateral epicondyle (43). Therefore, there is no need for an extensive debridement or weakening of the common extensor origin at the epicondyle. In this technique only 25% of the circle need to be visualized to identify the center of the circle and the isometric area. This new approach allows max-imal preservation of its origin and insertion and reduces dissection around this important structure, thereby avoiding denervation or injury to its vascular supply. Since the origin and insertion points and the graft harvesting are done using separate incisions, there is no compromise regarding accuracy of the intervention.

The diagnosis of PLRI is challenging to make without invasive procedures. History of the patient, plus clinical examination can help identify PLRI patients. A negative clinical instability test does not exclude PLRI as shown here where 14% of the patients had no clinical instability but when assessed arthroscopically, they did. The MRI is a good tool to asses for other soft tissue injuries and can help with the diagnosis in those patients where there is suspicion of PLRI but no positive instability tests (44). Incongruity of the elbow joint has been shown to be reliable markers to indicate PLRI (44) as well as being easier to asses and use as a screening tool (45). Another common finding in MRIs of patients with PLRI is injury to the common extensors.

Our study shows that radius subluxation in PLRI is common and it can be indicative of possible worse surgery outcomes. Especially interesting was the finding that patients with a suspected but not confirmed LCL tear had the worst outcomes of the cohort. This could indicate a concomitant pathology such as lateral epicondylopathy (46) or other unidentified elbow pathologies. Similar to the findings of the systematic review by Kholinne et al, our patients reported good to excellent outcomes (42) regardless of MRI findings.

Limitations

This study has some limitations with no pre-operative insatiably scores, so no direct comparison could be made before and after. In addition, the number of patients in this cohort, while one of the biggest for this kind of study is still small. No direct comparison could be made with different techniques for LUCL reconstruction. Future studies could try to compare different surgical approaches to identify the best one for different types of patients.

Conclusion

Clinical and patient results after LUCL reconstruction using a minimal invasive approach to protect the anconeus show excellent outcomes with a very low complication and re instability rate. This technique allows accurate graft placement and fixation with maximal protection of the active elbow stabilizers like the common extensor tendons and the anconeus muscle.

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Figures:

Figure 1: A) A 3-4 cm incisions is made at the ulnar side and the forearm fascia is incised, the upper border of the anconeus muscle (yellow arrow) is identified and retracted posteriorly, B) completely preserving its origin and insertion and exposing the ulnar insertion of the LUCL (yellow star).

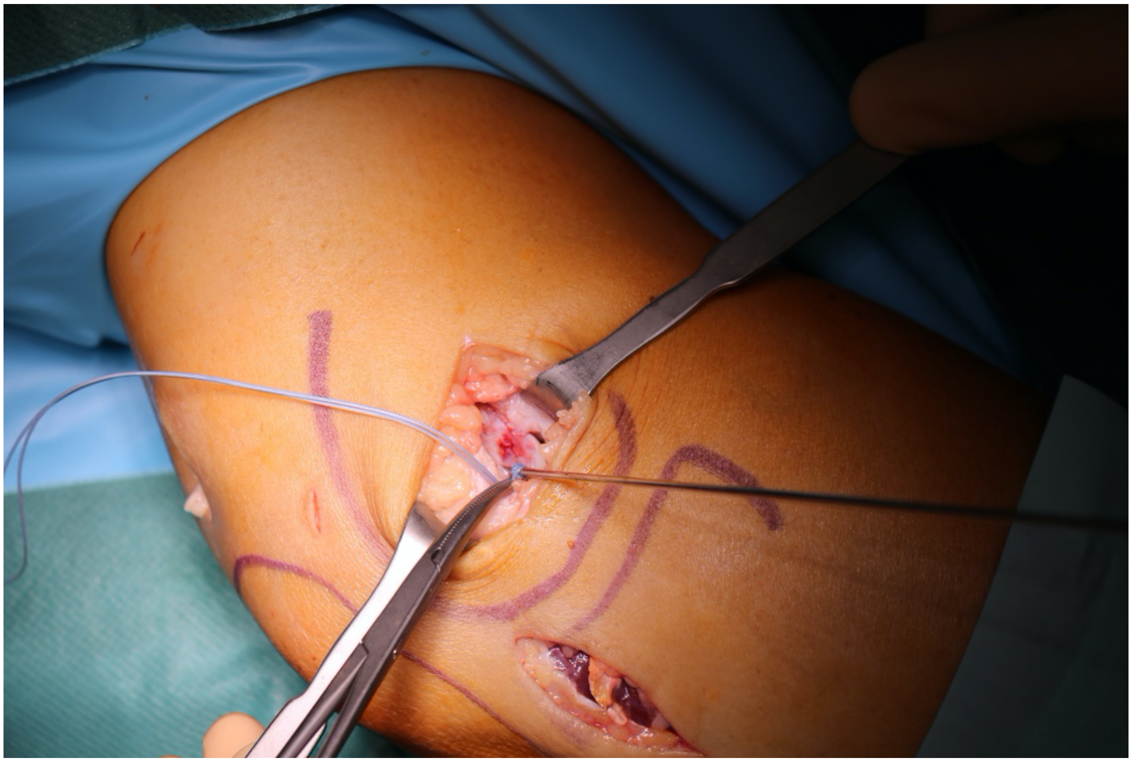

Figure 2: At the humeral side a part of the common extensor origin along with a part of the extensor carpi radialis is sharply elevated proximally to expose the lateral epicondyle with the origin of the lateral ligamentous complex. The anatomic origin of the LUCL is identified on the humerus and a Kirschner wire is inserted perpendicularly. Subsequently the remaining sutures are wound around the Kirschner wire and the elbow is brought into full extension and full flexion to test for the isometric insertion of the LUCL on the humerus.

Figure 3: After drilling a 4.5 mm hole along to the axis of the trochlea, a 5.5 mm knotless anchor (PEEK SwiveLock, Arthrex GmbH, Munich, Germany) loaded with the sutures is inserted, taking care to tighten the anchor and the graft with the elbow in a reduced position.

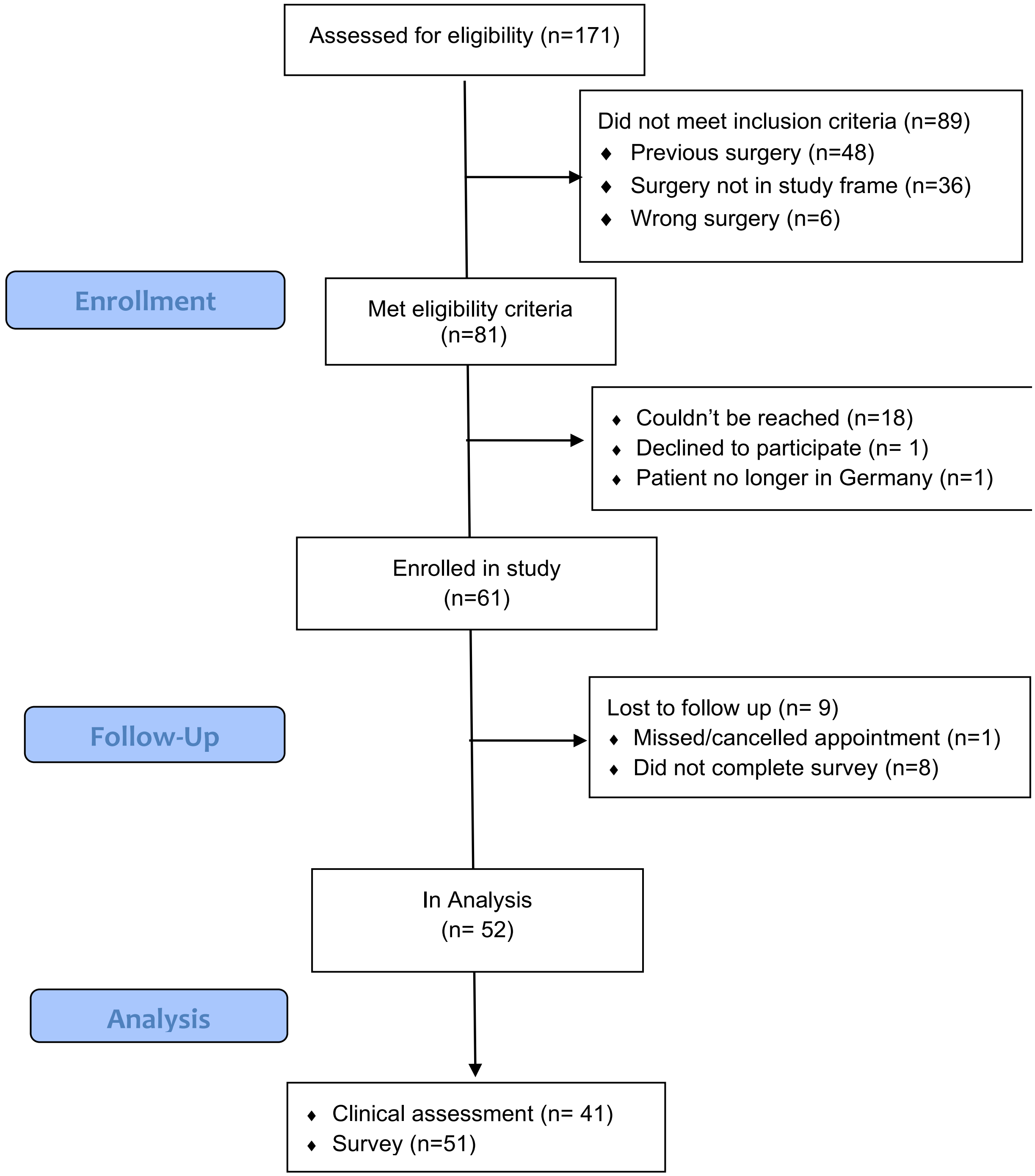

Figure 4. Flow chart of the study

Tables

Demographics of the cohort	
Age, mean (range), years	51 (20–76)
Sex, male/female, n(%)	31(60%)/21 (40%)
BMI, mean (range), kg/m²	26 (17-37)
Complaint time, mean (range), months	15 (2–72)
Corticosteroid injections, n(%)	28 (54%)
Trauma, n(%)	18 (35%)
Injury dominant arm, n(%)	36 (69%)
Follow up time, mean (range), months	53 (27-86)

Table 1. Demographic and clinical characteristics of the participants

Pre- and postoperative clinical results

	Patients	Pre- Surgery	Post- Surgery	P-Value
Clinical instability	41	33 (80.5%)	1 (2.4%)	<0.001*
Flexion	43	143.72° ± 8.387°	143.95° ± 3.867°	0.849
Extension	43	-1.98° ± 7.726°	-1.74° ± 3.916°	0.855
Supination	43	79.53° ± 4.857°	80.23° ± 4.076°	0.412
Pronation	43	79.53° ± 4.857°	80.23° ± 4.076°	0.412

*Significant

Table 2 Pre- and postoperative clinical results for clinical instability and range of motion

Clinician and Patient Reported outcomes

		MEPS	OES	VAS	SEV
	Patient History				
Etiology	No Trauma (n=33)	91.4 ± 12.2	40.3 ± 10.5	1.1 ± 2.1	87.7 % ± 13.7
	Trauma (n=18)	92.2 ± 12.0	40.6 ± 10.6	1.4 ± 2.2	88.3% ± 20.9
	p- value	0.74	0.78	0.75	0.33
Cortisone Injections	No injections (n=24)	90.2 ± 13.0	38.7 ± 12.6	1.63 ± 2.5	87.5 % ± 14.6
	Previous injections (n=27)	93.0 ± 11.2	41.9 ± 8.0	0.78 ± 1.7	88.3% ± 18.2
	p- value	0.492	0.526	0.170	0.243
	MRI findings				
Radius	Radius centered (n=27)	96.0 ± 9.4	43.0 ± 8,6	0.4 ± 1.2	92.2 % ± 13.4
	Not centered (n=24)	87.3 ± 13.3	37.5 ± 11.7	2.1 ± 2,5	83.1% ± 18.4
	p-value	0.017*	0.033*	< 0.001*	0.016*
LCL-Complex	no tear (n=11)	89.1 ± 13.2	41.6 ± 8.2	1.2 ± 1.8	84.1% ± 17.0
	suspected tear (n=16)	85.6 ± 12.5	34.4 ± 12.4	2.1 ± 2.7	81.5% ± 20.7
	confirmed tear (n=23)	97.3 ± 8.8	44.0 ± 8.5	0.4 ± 1.5	94.1% ± 10.6
	p-value	0.005*	0.011*	0.008*	0.026*
Overall Score (n=51)		91.7 ± 12.0	40.4 ± 10.5	1.2 ± 2.1	87.9 % ± 16.7

*Significant (p- value < 0.05)

Table 3. Difference of patient history and MRI findings in patient outcomes