

## Original Article

# The Rate of Medial Ulnar Collateral Ligament Repair Is Increasing While Reconstruction Remains the Most Common Procedure Overall Among Early-Career Orthopaedic Surgeons

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**Purpose:** To determine the practice patterns and complication rates in medial ulnar collateral ligament (MUCL) repair versus reconstruction procedures performed by early-career orthopaedic surgeons each year between 2010 and 2020, stratified by fellowship training and concomitant procedures performed, during their 6-month American Board of Orthopaedic Surgery (ABOS) Case List collection period. **Methods:** The ABOS database was queried for MUCL reconstruction and MUCL repair procedures reported by ABOS Part II Oral Examination examinees from 2010 to 2020. Surgeon fellowship training background, patient demographics, procedural diagnosis codes, complications, and concomitant procedures were recorded for each case. Differences between overall procedure rates and the associated complications reported were examined. Data regarding the specific injury pathology and other patient-specific characteristics for each case were not available. **Results:** In total, 187 primary procedures performed to address isolated MUCL injuries were reported. Of those, 83% (n = 155) were reconstructions and 17% (n = 32) were repairs. The annual percentage of MUCL repair increased from 10% (1/10) in 2010 to 38% (8/21) in 2020 (linear regression;  $R^2 = 0.56$ ,  $P < .05$ ). The cumulative complication rate for MUCL reconstruction (11.6%) was significantly lower than for MUCL repair (25%) from 2010 to 2020 ( $P < .05$ ). This remained true among subsets of cases from Orthopaedic Sports Medicine, Shoulder & Elbow, and or Hand Surgery fellowship-trained examinees, although only statistically significant in the Hand Surgery subset. Reported complication rates were not significantly different among cases in which concurrent ulnar nerve neuroplasty and/or transposition or concurrent elbow arthroscopy were performed. **Conclusions:** Among cases reported by ABOS Part II Oral Examination examinees from 2010 to 2020, there was an increasing rate of MUCL repair whereas MUCL reconstruction remained more common overall. Interestingly, the overall complication rates were significantly lower for MUCL reconstruction than for MUCL repair both in isolation and when concurrent procedures were performed. **Level of Evidence:** III, retrospective cohort study.

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**M**edial ulnar collateral ligament (MUCL) injuries in the overhead athlete can be devastating. They were considered career-ending before 1986, when Jobe et al.<sup>1</sup> reported on their initial experiences with MUCL reconstruction. The procedure subsequently has demonstrated return to play rates between 65% and 95% in professional athletes at 12 months' post-operatively.<sup>2-5</sup> However, professional athletes comprise the minority of patients seen with MUCL injuries. Recent data have shown that with increased athletic participation and single-sport specialization, there was a 22-fold increase in MUCL reconstructions in adolescents between 1994 and 2010.<sup>6,7</sup> However, MUCL injuries in young adolescent patients may have a different pathophysiology compared with those sustained by professionals, with less chronic degeneration of the ligament.<sup>8</sup>

With focal, acute ligament damage, and good healing potential, some surgeons have instead advocated for MUCL repair. In some patient populations, there is evidence to suggest that repair may allow for faster recovery and greater rates of return to play compared with traditional reconstruction.<sup>9-12</sup> Argo et al<sup>9</sup> examined this in a cohort of young, female, primarily underhand throwing athletes. Their data showed that MUCL repair provided consistent return to play at a high level postoperatively, and their MUCL repair cohort had both faster recovery and a greater rate of return to play compared with previously reported reconstructions. They recommended MUCL repair in female athletes at or below the collegiate level if the ligament is not extensively damaged. Savoie et al<sup>10</sup> examined a cohort of young male and female athletes, primarily overhand throwers. They found that repair is a viable option for proximal or distal MUCL injuries and recommended considering it in athletes at or below the college level with those injury patterns. Richard et al<sup>11</sup> examined MUCL injuries in a cohort of primarily young, collegiate-level male patients, including various types of athletes and nonathletes. They showed that repair was effective at restoring valgus stability and allowed for functional return and greater rates of return than previously reported for MUCL reconstruction. Dugas et al<sup>12</sup> examined MUCL repair in a cohort of young, primarily male, high school and college baseball pitchers with both acute and chronic injuries. Their data showed similar recovery times after repair as previously reported after MUCL reconstruction, but with a greater rate of return to play. There is also supportive biomechanical data indicating that MUCL repair with augmentation can provide similar time-zero failure strength and increased gap resistance compared with traditional reconstruction.<sup>13</sup>

The purpose of this study was to determine the practice patterns and complication rates in MUCL repair

versus reconstruction procedures performed by early-career orthopaedic surgeons each year between 2010 and 2020, stratified by fellowship training and concomitant procedures performed, during their 6-month American Board of Orthopaedic Surgery (ABOS) Case List collection period. The authors hypothesized that these data would show an increase in the rate of MUCL repairs performed over the last 10 years among early-career fellowship-trained surgeons. A secondary hypothesis was that there would not be a significant difference in complication rates associated with the 2 procedures.

## Methods

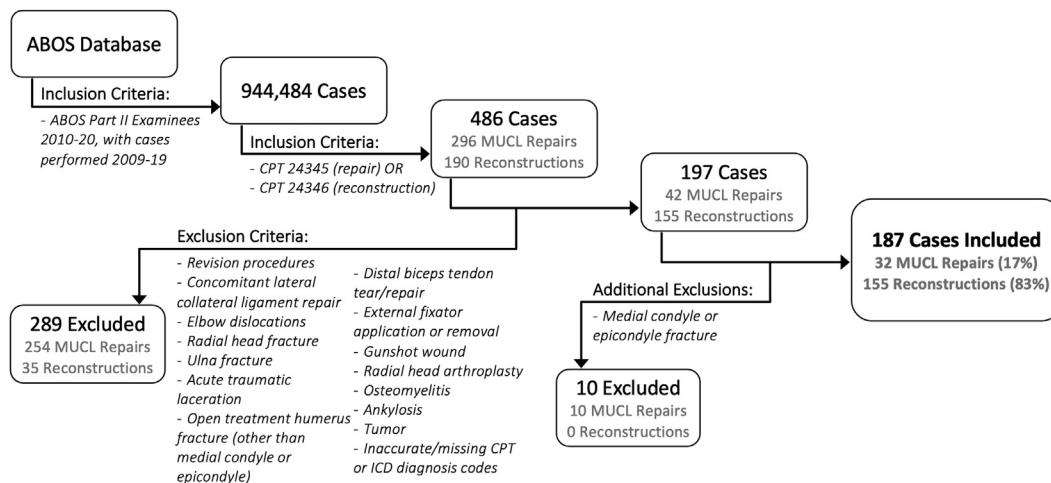
The research protocol for this retrospective study was reviewed by the institutional review board at the institution where the study was performed and was exempted (Virginia Commonwealth University institutional review board HM20020402). Candidates applying for Part II Examination are informed by the ABOS that the deidentified data submitted as part of the process of board certification may be used for research purposes.

### Data Collection

The ABOS database contains information that is self-reported by candidates in preparation for the Part II Oral Examination. All candidates are practicing orthopaedic surgeons who have passed the ABOS Part I Board Certification Written Examination after completing an Accreditation Council for Graduate Medical Education—accredited orthopaedic surgery residency. As part of the ABOS Board Certification Part II Oral Examination process, candidates submit data for each surgical procedure performed over a 6-month period within their first 22 months of active practice.

Data within the ABOS database include the procedure date, surgeon fellowship training type, *International Classification of Diseases, Tenth Revision* (ICD-10) code, Current Procedural Terminology (CPT) surgical procedure codes, patient age, patient sex, and associated complications. Each candidate enters the information based on his or her own subjective patient assessment, and no patient-derived data are included.

The requested search query from the ABOS database included all MUCL reconstruction (CPT code 24346) and MUCL repair (CPT code 24345) procedures reported by ABOS Part II Examinees for the years 2010 to 2020. The procedures reported during this time period were performed by ABOS Part II Examinees during their respective case collection periods between January 2009 and December 2019. The ABOS database query was submitted on April 10, 2020, subsequently approved, and the requested data were received on August 14, 2020. Patient demographics including age



**Fig 1.** Flowchart shows application of study inclusion and exclusion criteria to all MUCL repair and reconstruction procedures recorded in the ABOS Database from 2010 to 2020. (ABOS, American Board of Orthopaedic Surgery; MUCL, medial ulnar collateral ligament.)

and sex, ICD-10 codes, complications, and CPT codes for concomitant procedures were recorded as well as fellowship training for the surgeon. MUCL surgeries that were done in the setting of fractures, elbow dislocations, traumatic lacerations, infections, or tumors were excluded based on ICD-10 diagnosis codes and additional concurrently reported CPT codes (Fig 1). Data were analyzed to determine the rate of each surgical technique (reconstruction vs repair) performed as a percentage of total cases performed during each individual year, and for the cumulative 10-year study period. Complication rates after reconstruction and repair were determined for each individual year and for the cumulative 10-year period. Complications were reported by examinees as 1 of 5 general categories: anesthetic, medical, surgical, reoperation, and readmission. The overall complication rate for all MUCL reconstruction and repair procedures was determined. A subgroup analysis was performed on all cases performed by examinees from the 3 fellowship training backgrounds that reported the greatest number of MUCL procedures: Orthopaedic Sports Medicine, Shoulder & Elbow, and Hand Surgery. Complication rates for the procedures among each of the 3 fellowship subspecialties were determined. The 2 most common concomitant procedures reported were neuroplasty and/or transposition of ulnar nerve (CPT 64718) and elbow arthroscopy (CPT 29830, 29834, 29835, 29837, 29838). The subsets of cases where MUCL repair or reconstruction was reported along with these concomitant procedures were analyzed to compare their complication rates with those of isolated MUCL reconstruction and repair.

### Statistical Methods

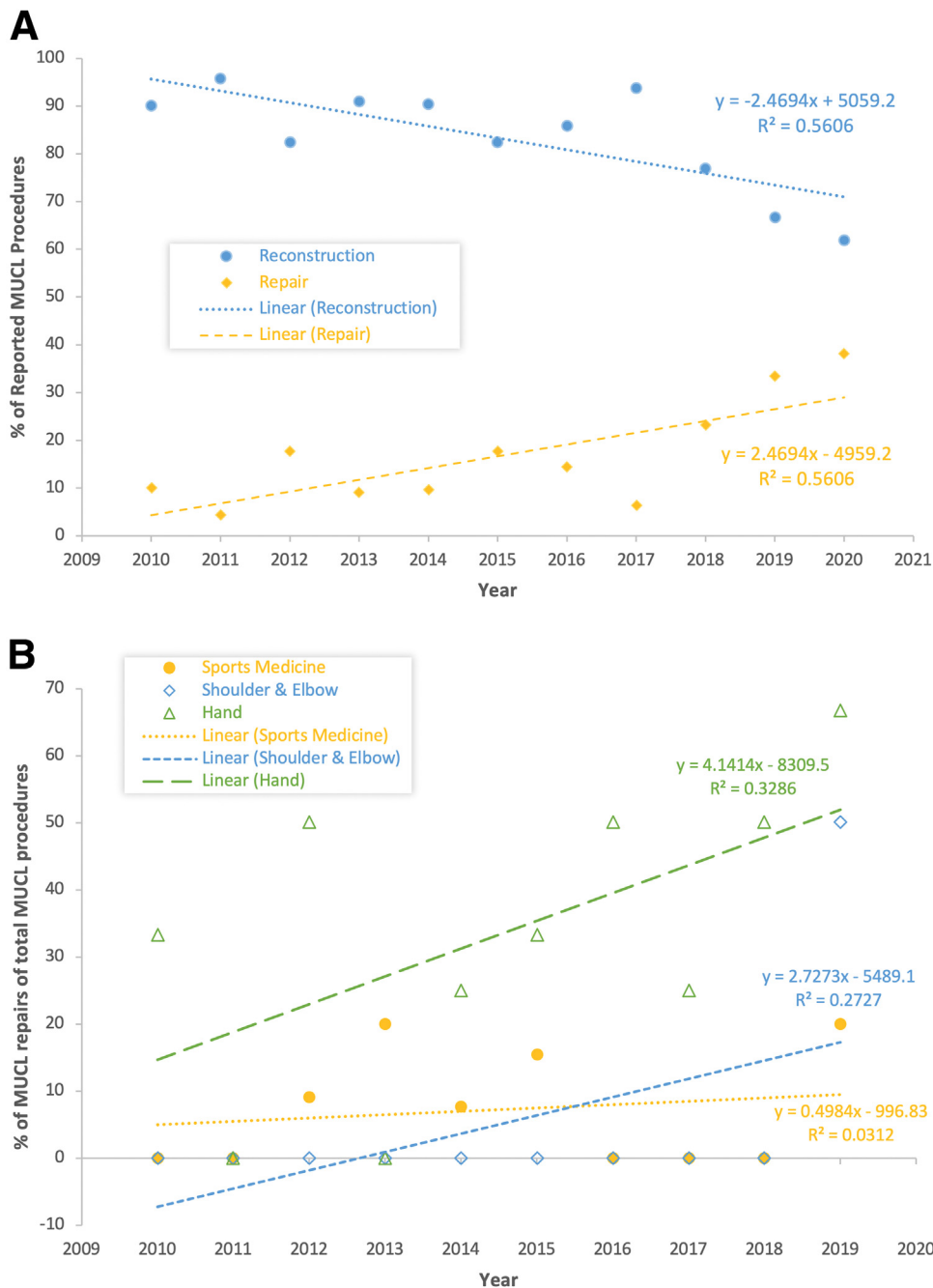
Descriptive statistics were calculated for all data. Microsoft Excel, Version 16.63.1 (Microsoft, Redmond,

WA) and IBM SPSS, Version 28.0 (IBM Corp., Armonk, NY) were used for all statistical analysis. A linear regression model was used to evaluate the procedures performed each year. A comparison of categorical variables between MUCL reconstruction and repair was performed using a  $\chi^2$  analysis. A  $P < .05$  was considered statistically significant.

### Results

During the years 2010 to 2020, ABOS Part II Oral Examination candidates reported a total of 486 MUCL procedures (performed between 2009 and 2019). Of these, 187 met inclusion criteria. All nonprimary MUCL injuries and MUCL surgeries that were done in the setting of fractures, elbow dislocations, traumatic lacerations, infections, or tumors were excluded based on reported ICD-10 diagnosis codes and additional concurrently reported CPT codes to reduce possible confounding factors (Fig 1). Of the 187 included MUCL procedures, 155 (83%) were reconstructions and 32 (17%) were repairs. The average ages of the patients who underwent MUCL reconstruction and repair were 21.6 and 21.7 years old, respectively, with no significant age difference between groups ( $P = .9$ ). The number of patients younger than 16 years old who underwent MUCL reconstruction and repair were 8 of 155 (5%) and 6 of 32 (19%), respectively, with no significant difference between the groups. Patients undergoing the reported procedures were predominantly male. There was no significant difference in sex distribution between groups, with 91.6% (142/155) male patients in the reconstruction group and 88% (28/32) male patients in the repair group ( $P = 0.5$ ).

The annual percentage of MUCL repairs within the data set increased from 10% (1/10) in 2010 to 38% (8/21) in 2020 (linear regression;  $R^2 = 0.56$ ,  $P < .05$ ), whereas the annual percentage of MUCL



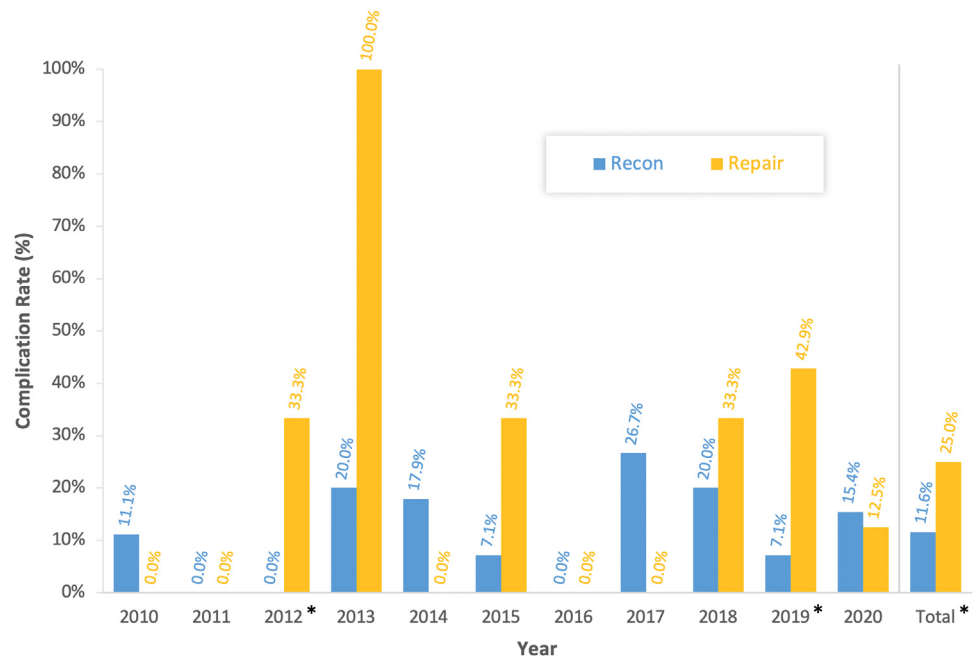
**Fig 2.** (A) Yearly percentages of MUCL reconstruction and repair procedures based on the total number of included MUCL procedures reported to the ABOS each year from 2010 to 2020. Linear regression models for each over the course of the study period are shown. (B) Yearly percentages of MUCL repair procedures based on the total number of included MUCL procedures reported to the ABOS by subgroups of Sports Medicine, Shoulder & Elbow, and Hand fellowship-trained surgeons each year from 2010 to 2020. Linear regression models for each over the course of the study period are shown. (ABOS, American Board of Orthopaedic Surgery; MUCL, medial ulnar collateral ligament.)

reconstructions declined from 90% (9/10) in 2010 to 62% (13/21) in 2020 (linear regression;  $R^2 = 0.56$ ,  $P < .001$ ) (Fig 2A). Annual percentages of MUCL repairs reported by subsets of Sports Medicine, Shoulder & Elbow and Hand fellowship-trained surgeons each year from 2010 to 2020 are shown in Figure 2B.

Complication rates for MUCL reconstruction were significantly lower than for repair in the individual years of 2012 and 2019, and cumulatively among all included cases 2010 to 2020 ( $P < .05$ ,  $\chi^2$  analysis) (Fig 3). The relative risk of complications for reconstruction

compared with repair was 0.47 (95% confidence interval, 0.09-0.83). For MUCL reconstruction ( $n = 155$ ), there were 0 anesthetic complications, 1 medical complication (unspecified), 17 surgical complications (12 nerve palsy/injury, 1 wound healing, 1 arthrofibrosis, 1 skin blister, 2 unspecified), with no reoperations/readmissions. Of the 12 patients with nerve palsy/injury in the MUCL reconstruction group, 5 underwent concomitant ulnar nerve transposition (42%). For MUCL repair ( $n = 32$ ), there were 0 anesthetic complications, 2 medical complications (deep venous

**Fig 3.** Annual and cumulative overall complication rates (including anesthetic, medical, surgical, re-operation, and readmission) for MUCL reconstruction and repair based on the total number of included MUCL procedures and associated complications reported to the ABOS each year from 2010 to 2020. Statistically significant differences in complication rates between reconstruction and repair were identified in 2012, 2019, and cumulatively for the full study period from 2010 to 2020 ( $P < .05$ ,  $\chi^2$  analysis; \* = statistical significance). (ABOS, American Board of Orthopaedic Surgery; MUCL, medial ulnar collateral ligament.)



thrombosis, dermatologic complaint), and 7 surgical complications (3 nerve palsy/injury, 1 wound healing, 1 infection requiring reoperation and admission, 1 failure of ligament repair requiring reoperation, and 1 unspecified). Of the 3 patients with nerve palsy/injury in the MUCL repair group, 2 underwent concomitant ulnar nerve transposition (66%).

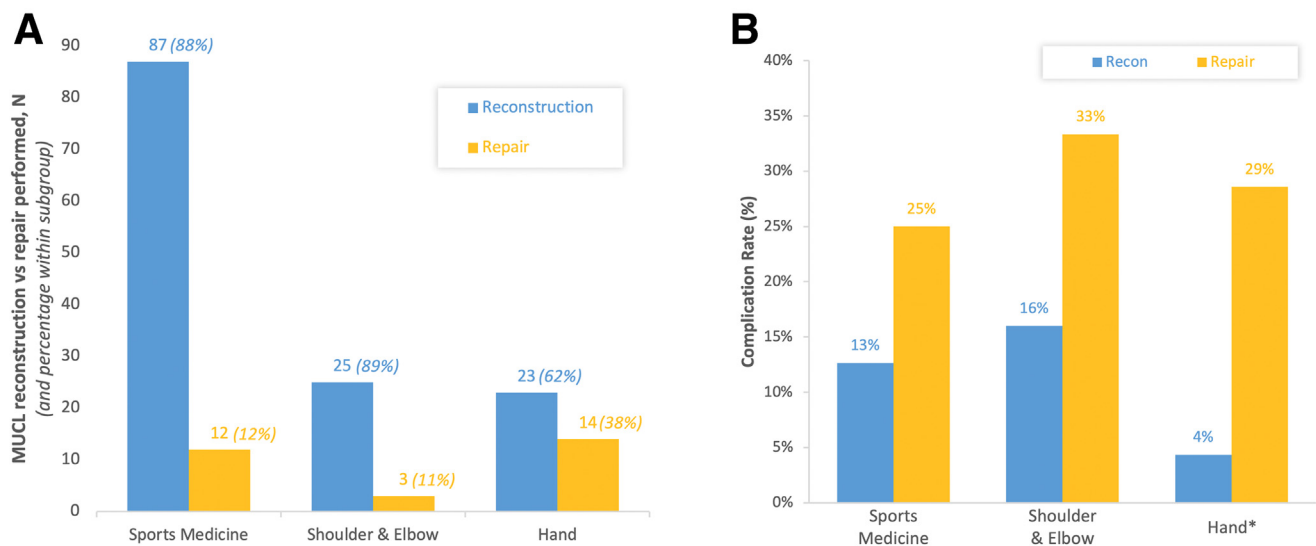
Orthopaedic Sports Medicine fellowship-trained surgeons performed the greatest number of included MUCL procedures ( $n = 99$ ). However, Surgery of the Hand fellowship-trained surgeons performed MUCL repair at the greatest rate relative to reconstruction (62% vs 38%) in comparison with Orthopaedic Sports Medicine (12% vs 87%) and Shoulder & Elbow (11% vs 89%) fellowship-trained surgeons (Fig 4A). MUCL repair was associated with a greater complication rate within each of those subspecialty subsets; however, this was only statistically significant among cases performed by Hand fellowship-trained surgeons (Fig 4B).

The most common concurrently performed procedures based on reported CPT codes were neuroplasty and/or transposition of ulnar nerve and elbow arthroscopy. Ulnar nerve neuroplasty and/or transposition was performed along with 33% (51/155) of MUCL reconstruction procedures and 25% (8/32) of MUCL repair procedures. Elbow arthroscopy was performed along with 6% (9/155) of MUCL reconstruction procedures and 0% of MUCL repairs. When these procedures were concurrently performed, there was no statistically significant difference in complication rates in comparison with isolated MUCL repair/reconstruction (Table 1).

## Discussion

This study identified an increasing rate of MUCL repair relative to MUCL reconstruction procedures performed by early-career fellowship-trained surgeons during the recent 10-year study period, which is consistent with the initial hypothesis. The study also found a significantly lower complication rate for MUCL reconstruction than for repair, an unexpected finding that was inconsistent with the secondary hypothesis.

The increase in MUCL repair procedures performed by the group of early-career surgeons examined in this study coincides with recent literature reporting that augmented repair provides a robust construct that allows for rapid return to sport in amateur athletes. The literature has supported this particularly in the population of younger patients presenting with a more acute injury pathophysiology.<sup>12,13</sup> One study showed that 92% of patients who had undergone MUCL repair with internal brace suture augmentation underwent an accelerated rehabilitation schedule and were able to return to competition at a mean time of 6.7 months.<sup>12</sup> This is in contrast to a recent study on MUCL reconstruction, which showed average return to sport at 11.6 months.<sup>14</sup> With increasing literature supporting the clinical efficacy and outcomes of MUCL repair, it seems likely that an increasing rate of MUCL repair relative to reconstruction procedures will continue within Orthopaedic Sports Medicine, Shoulder and Elbow, and Hand Surgery fellowship-trained surgeons. However, it must be noted that the ABOS database examined in this study does not include potentially influential information such as specific imaging findings, MUCL tear pattern or location,



**Fig 4.** (A) Number and cumulative percentages for MUCL reconstruction versus MUCL repair procedures reported to the ABOS by subgroups of Sports Medicine, Shoulder & Elbow and Hand fellowship-trained surgeons during the full study period from 2010 to 2020. (B) Cumulative complication rates (including anesthetic, medical, surgical, reoperation, and readmission) for MUCL reconstruction and repair procedures reported to the ABOS by subgroups of Sports Medicine, Shoulder & Elbow and Hand fellowship-trained surgeons during the full study period from 2010 to 2020. A statistically significant difference in complication rates after MUCL reconstruction and MUCL repair was identified in the subset of procedures reported by Hand fellowship-trained surgeons ( $P < .05$ ,  $\chi^2$  analysis. \* = statistical significance). (ABOS, American Board of Orthopaedic Surgery; MUCL, medial ulnar collateral ligament.)

injury chronicity, ligament tissue quality, patient level of athletic participation, or return to sport time for the surgical cases examined. Still, there is relatively recent epidemiological data to support a predicted increase in the rate of repair for MUCL injuries. A study of Division I baseball players found a significant increase in the rate of repair over a 3-year period including the seasons from 2016 to 2017 to 2018 to 2019.<sup>15</sup> An analysis of a private payer database from 2007 to 2017 found an increasing incidence of MUCL injuries, and that the rates of repair were generally increasing particularly within the adolescent patient population.<sup>16</sup>

In addition to the increasing rate of MUCL repairs relative to reconstructions, this study demonstrated a greater rate of complications after ligament repair compared with ligament reconstruction. This appeared to be true regardless of whether any of the most common concomitant procedures were performed (ulnar nerve neuroplasty and/or transposition, diagnostic elbow arthroscopy, elbow arthroscopy with loose/foreign body removal, elbow arthroscopy with partial synovectomy, elbow arthroscopy with limited debridement, or elbow arthroscopy with extensive debridement). The most common complication after both MUCL reconstruction and repair was ulnar nerve palsy/injury, which is consistent with findings reported in the literature.<sup>10,17,18</sup> On an annual basis, this study only demonstrated a statistically significant increase in complication rates after MUCL repair relative to reconstruction in 2 of 10 years examined: 2012 and

2019. However, when the data were analyzed in aggregate, a statistically significant cumulative greater complication rate after MUCL repair was demonstrated. In subgroup analysis, a statistically significant increase in the complication rate after MUCL repair was only demonstrated among the cases reported by Hand fellowship-trained surgeons. This is likely because Hand Surgery fellowship-trained surgeons reported the greatest within-subgroup proportion of MUCL repairs relative to reconstruction and should not be interpreted as a finding attributable to subspecialty training background. Subgroup analysis of the data from the other subspecialties was underpowered to detect differences in complication rates. Regarding the increased complication rate after repair relative to reconstruction, it is difficult to draw conclusions about the reasons for differences in complication rates after the procedures based on this data. The reported data are limited to ICD-10 diagnosis codes and procedural CPT codes and thus lack additional details about the true clinical status of the patients or indications for surgery in each case.

As MUCL repair appears to be increasing in popularity, it will be important to consider the indications for the procedure to ensure that optimal results are achieved and complications are minimized. When deciding between MUCL repair and reconstruction, surgeons should consider the tissue quality of the injured ligament, the location of the tear, the acuity of injury, the age of the patient, and their level of athletic participation. Repair might be considered in cases of proximal or distal

**Table 1.** Most Common Concomitant Procedures Performed With MUCL Procedures and Their Incidences, Complication Rates, and Statistical Significance When Compared With Complication Rates of Isolated MUCL Procedures Included in the Study

Procedure (Reported CPT Codes)*	Rate Performed (%)	Complication Rate (%)	Significance of Complication Rate vs MUCL Procedure Alone (P Value)
<b>MUCL reconstruction (n = 155)</b>			
MUCL reconstruction alone (24346)	57% (88/155)	8% (7/88)	—
MUCL reconstruction + ulnar nerve decompression/transposition (24346 + 64718)	33% (51/155)	18% (9/51)	.08
MUCL reconstruction + elbow arthroscopy (24346 + 29830 or 29834 or 29835 or 29837 or 29838)	6% (9/155)	29% (2/9)	.16
<b>MUCL repair (n = 32)</b>			
MUCL repair alone (24345)	31% (10/32)	20% (2/10)	—
MUCL repair + ulnar nerve decompression/transposition (24345 + 64718)	25% (8/32)	50% (4/8)	.18
MUCL repair + elbow arthroscopy (24345 + 29830 or 29834 or 29835 or 29837 or 29838)	0% (0/32)	N/A	N/A

NOTE. No significant differences in overall complication rates were observed when concomitant procedures were performed. CPT, Current Procedural Terminology; MUCL, medial ulnar collateral ligament; N/A, not applicable.

\*Procedure CPT Code Legend

24346: Reconstruction MUCL

24345: Repair MUCL

64718: Neuroplasty and/or transposition; ulnar nerve at elbow

29830: Arthroscopy elbow – diagnostic

29834: Arthroscopy elbow – removal of loose/foreign body

29835: Arthroscopy elbow – partial synovectomy

29837: Arthroscopy elbow – debridement limited

29838: Arthroscopy elbow – extensive

injuries with good ligamentous quality, particularly in younger, nonprofessional athletes.<sup>10</sup> In cases in which there is concern for poor ligamentous quality, mid-substance tears, or larger tears, patients may be better served with reconstruction.<sup>10</sup> This is especially true in professional athletes in whom MUCL repair has been shown to be far less successful compared with reconstruction.<sup>19</sup> In addition, acute MUCL injuries may be more suitable for repair, whereas chronic ligamentous insufficiency should more likely be treated with reconstruction.<sup>11</sup> The term “repair” as it has been used in this article encompasses all MUCL repair techniques because the level of differentiation is limited to that provided by CPT codes reported in the ABOS database. However, it should be noted that techniques such as internal brace suture augmentation are commonly implemented as a component of MUCL repair and likely contribute significantly to the success of the procedure. Like classic MUCL repair, the literature suggests that repair with internal brace augmentation in the adolescent population provides an opportunity for accelerated therapy and return to play.<sup>20</sup> As MUCL repair is increasingly

considered as an alternative to reconstruction, outcomes can be optimized with appropriate application of surgical indications and appropriate use of techniques such as internal brace augmentation.

### Limitations

Limitations in this study include those inherent to a retrospective evaluation of a large database. Even with the use of a large database, the cohorts analyzed here (particularly the UCL repair cohort) were relatively small for a 10-year period. The authors felt that it was important to apply relatively extensive exclusion criteria to identify only primary, uncomplicated MUCL procedures. The exclusion criteria applied did play a role in limiting the power of the study. Reporting bias may be present as the self-reported complications may not have been reported consistently by all candidates. There is also the possibility that selection bias and the Hawthorne effect influenced the cases identified in this study, as surgeons may have modified their surgical decision-making and patient selection during their known 6-month ABOS Part II case collection periods.

This study is also limited by the information available within the examined data set, which is limited to diagnostic and procedural codes. It does not include additional details about the indications for surgery, patient occupation, participation in athletic and recreational activities, length of time between injury and surgery, trials of nonoperative treatment and physical therapy, success in returning to sport or the time needed to do so, or specific injury characteristics. Patient-reported outcomes were not recorded in the ABOS database and thus were not available for analysis. All of these limitations impair the ability to draw conclusions regarding the overall success of the procedures in examined in the study, as complication rates and surgical survivorship do not necessarily fully reflect clinical outcomes. The ability to draw explanatory conclusions regarding the differences in complication rates observed in this study is limited by the lack of details in the ABOS database regarding the nature of complications or ultimate outcomes. Analyses requiring knowledge of the specific pathology, level of athletic participation, return to sport time, and other patient-specific data for these surgical cases were unable to be conducted due to the limited information in the ABOS database.

This study was underpowered to detect differences in complication rates between subsets based on fellowship training background when comparing repair versus reconstruction. The Sports Medicine and the Shoulder and Elbow-trained surgeon cohorts would have needed 199 and 279 additional cases, respectively, to reach sufficient power for subgroup analysis this study. Post-hoc power analysis demonstrated these 2 subgroups to be at 19.9% and 12.2% of the power needed to detect significant differences in complication rates.

Lastly, we acknowledge that it may be difficult to extrapolate complications and outcomes from ABOS Part II Oral Examination candidates to surgeons with more experience or the overall population of surgeons treating these injuries, as there may be a learning curve for early career surgeons who are still mastering MUCL repair and reconstruction techniques.

### Conclusions

Among cases reported by ABOS Part II Oral Examination examinees from 2010 to 2020, there was an increasing rate of MUCL repair while MUCL reconstruction remained more common overall. Interestingly, the overall complication rates were significantly lower for MUCL reconstruction than for MUCL repair both in isolation and when concurrent procedures were performed.

### Acknowledgments

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