Defining the Critical Elements of the Most Common Arthroscopic Procedures: A Consensus of Orthopaedic Sports Medicine Surgeons

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Disclosures can be found in Additional Information at the end of the article

Abstract

Objective

To define the critical elements of common procedures in arthroscopic surgery.

Methods

A survey was administered to surgeons associated with the American Orthopaedic Society for Sports Medicine (AOSSM) to determine the critical elements for four common arthroscopic procedures: anterior cruciate ligament (ACL) reconstruction, knee arthroscopy with meniscal debridement or repair, rotator cuff repair (RCR), and capsulorrhaphy for anterior glenohumeral instability (Bankart repair). Respondents were asked which steps necessitated their direct supervision. The level of experience and practice demographics were also recorded.

Results

For all applicable procedures, patient positioning and closure were not considered critical steps. Establishing arthroscopic portals was critical for all procedures, except knee arthroscopy. Diagnostic arthroscopy was only critical in ACL reconstruction. Private practice surgeons considered every step of these common procedures to be critical elements. Less experienced surgeons were more likely to regard certain aspects of a procedure critical. Surgeons with >15 years of experience considered diagnostic arthroscopy critical to all procedures, whereas those with <15 years of experience did not. Unlike surgeons with a resident as first assist, surgeons with a physician assistant (PA) or nurse practitioner (NP) found every step of each procedure to be critical except closure and positioning.

Conclusion

Across all procedures, only patient positioning and closure were consistently regarded as non-critical elements. There were significant differences in responses according to experience and practice setting. Future research is necessary to determine the implications of these findings and guide the definition of the "critical portions" of surgery.
Introduction

Every operation is a sequence of numerous, distinct steps that carry their own potential for complications. Academic teaching hospitals train resident surgeons by allowing them to assist in these operations and take an increasingly important role as both their knowledge and skills mature. The notion of “critical” steps of surgery, or those requiring the presence and direct supervision of the attending surgeon, has been implemented into nearly every document pertaining to surgery, from patient consent forms to national guidelines, and even billing clauses [1-2]. Recently, the Boston Globe’s investigation on the practice of concurrent surgeries drew controversy over “double booking” – the process of overlapping surgical cases booked under one attending surgeon in multiple rooms [1,3]. Questions of patient safety, ethical consent, health care costs, and medical education and training have arisen from this investigation despite the clear language in patient consent forms that reassures patients that an attending surgeon will be present for all “critical parts” of the procedure.

In April 2016, the American College of Surgeons’ (ACS’) Statement of Principles was revised and distinguishes between “concurrent” and “overlapping” surgeries based on whether the “critical steps” of the two procedures occur simultaneously or sequentially [4]. This statement deems concurrent surgeries inappropriate, as they do not allow the presence of an attending surgeon during the “critical” steps of surgery occurring simultaneously. The Center for Medicare and Medicaid Services (CMS) has also declared that a supervising physician must be present for all “critical portions” of a procedure in order to qualify for reimbursement [2]. While the language in these consent forms is consistent across academic centers, this notion of “critical parts” of surgery still remains unclear, as it is open to various interpretations. To date, there has been no study establishing criteria for critical surgical steps in arthroscopic surgery, although it has been implied that such steps are “defined” for all common surgical procedures [5].

The purpose of the current study was to define the critical elements in four of the most common arthroscopic sports medicine procedures: anterior cruciate ligament (ACL) reconstruction, rotator cuff repair (RCR), knee arthroscopy, and anterior capsulorrhaphy with labral repair for glenohumeral instability (Bankart procedure). Herein, we report the results of a survey distributed to orthopedic sports medicine surgeons. We hypothesized that for each procedure, patient positioning, portal establishment, diagnostic arthroscopy, and closure would not be considered critical steps.

Materials And Methods

A web-based survey was developed by the authors at our institution and administered using Qualtrics software (Provo, UT, US), a survey platform for online data collection and analysis. The questionnaire consisted of 11 questions. The first seven questions were directed at surgeon demographics (years in practice, private versus academics, urban versus rural, geographic location, fellowship training, and first assistant). Each of the final four questions focused on a particular procedure, specifically ACL reconstruction, RCR, knee arthroscopy with meniscal repair for glenohumeral instability (Bankart procedure). Herein, we report the results of a survey distributed to orthopedic sports medicine surgeons. We hypothesized that for each procedure, patient positioning, portal establishment, diagnostic arthroscopy, and closure would not be considered critical steps.
procedure were selected by respondents, a sub-menu appeared with further questions. For the purpose of this study, a "critical" element of arthroscopic surgery was defined as a surgical step selected by the majority of respondents (>50%).

A link to the survey was emailed to 2016 members of the American Orthopaedic Society for Sports Medicine (AOSSM). Between August and September 2017, 343 physicians responded to the survey, corresponding to a response rate of 17% (343/2016).

Statistical analyses were performed with SPSS (IBM v24.0, Chicago, IL, US). An unadjusted univariate analysis was performed using independent sample t-tests for continuous data and Chi-squared or Fisher exact tests for categorical variables. Correlations between continuous variables were examined using the Pearson correlation coefficient test. Statistical significance was defined as p < 0.05.

Results

A total of 343 surgeons responded to the survey. Responder demographics are presented in Table 1. The majority of respondents practiced in a major city (55.9%) with over 15 years of surgical experience (55%). Among respondents, the first assistant during surgery was a resident physician (30%), a physician assistant (PA) (45.9%), a nurse practitioner (NP) (4.1%), or other (20%). For all procedures, patient positioning and closure were not designated as critical elements. Diagnostic arthroscopy was not considered critical in any procedure, except for ACL reconstruction. The establishment of portals was a critical element of all procedures except knee arthroscopy.

| All Responders (%)                     |            |
|----------------------------------------|------------|
| No. of Attending Surgeons              | 343 (17)   |
| Years in Practice, n (%), N=340        |            |
| 1-5 Years                              | 30 (8.8)   |
| 6-10 Years                             | 85 (25.0)  |
| 11-15 Years                            | 38 (11.2)  |
| 15+ Years                              | 187 (55.0) |
| Sports Medicine/Shoulder Fellowship Completed, n (%), N=341 |            |
| Sports Medicine                        | 306 (89.7) |
| Shoulder                               | 7 (2.1)    |
| Neither                                | 28 (8.2)   |
| Practice Classification, n (%), N=341  |            |
| Academic                               | 83 (24.3)  |
| Private                                | 183 (53.7) |
| Privademic                             | 75 (22.0)  |
| Practice Location, n (%), N=340        |            |
**TABLE 1: Responder demographics**

| Practice Location Classification, n (%), N=340 |       |
|---------------------------------------------|-------|
| Northeast                                   | 102 (30.0) |
| South                                       | 77 (22.6) |
| West                                        | 40 (11.8) |
| Central                                     | 85 (25.0) |
| Southwest                                   | 29 (8.5) |
| Outside of USA                              | 7 (2.1) |

| Practice Location Classification, n (%), N=340 |       |
|---------------------------------------------|-------|
| Major City                                  | 190 (55.9) |
| Minor City                                  | 130 (38.9) |
| Rural                                       | 20 (5.9) |

| Cases Performed Each Year, n (%), N=341 |       |
|----------------------------------------|-------|
| <100                                    | 6 (1.8) |
| 100-250                                 | 68 (19.9) |
| 250-500                                 | 186 (54.5) |
| 500-700                                 | 57 (16.7) |
| >700                                    | 24 (7.0) |

| First Assistant During Surgery, n (%), N=340 |       |
|---------------------------------------------|-------|
| Resident (MD/DO)                            | 102 (30.0) |
| Physician Assistant                        | 156 (45.9) |
| Nurse Practitioner                         | 14 (4.1) |
| Other                                      | 68 (20.0) |

**Among all respondents**

For knee arthroscopy, meniscal debridement (66%), meniscal repair (95%), and chondral procedures (79%) were critical. When performing a meniscal debridement, determining which tears require meniscectomy (64%), identifying the proper amount of meniscus to resect (65.3%), and performing the meniscectomy (53%) were all considered critical. Additionally, all aspects of performing a meniscal repair were critical (Table 2). For chondral procedures, microfracture was deemed critical (76%) while performing a chondroplasty was not (47%).
### Overall Knee Arthroscopy Critical Elements, n (%), N=343

| Procedure                                      | n   | (%)  |
|------------------------------------------------|-----|------|
| Establishing Portals                           | 154 | (44.9) |
| Diagnostic Arthroscopy                        | 166 | (48.4) |
| Meniscal Debridement                          | 225 | (65.6) * |
| Meniscal Repair                               | 327 | (95.3) * |
| Chondral Procedures                           | 271 | (79.0) * |
| Closure                                       | 12  | (3.5) |
| None                                          | 5   | (1.5) |
| Positioning                                   | 47  | (13.7) |

### Knee Arthroscopy Critical Establishing Portal Elements, n (%), N=343

| Portal Type                                      | n   | (%)  |
|-------------------------------------------------|-----|------|
| Anterior Portals                                | 141 | (41.1) |
| Posterior Portals for Meniscal Root Repair      | 143 | (41.7) |

### Knee Arthroscopy Critical Meniscal Debridement Elements, n (%), N=343

| Debridement Type                                | n   | (%)  |
|-------------------------------------------------|-----|------|
| Identifying which Tears Need Meniscectomy vs Repair | 218 | (63.6) * |
| Identifying Amount of Meniscal Debridement      | 217 | (63.3) * |
| Performing Meniscectomy with Shaver and/or Biter | 180 | (52.5) * |

### Knee Arthroscopy Critical Meniscal Repair Elements, n (%), N=343

| Repair Type                                    | n   | (%)  |
|-------------------------------------------------|-----|------|
| Establishing Technique (All inside/Outside In/ Inside Out) | 284 | (82.8) * |
| Approach if using Outside In/ Inside Out        | 268 | (78.1) * |
| Identifying Location of Suture Placement       | 282 | (82.2) * |
| All-Inside Repair                              | 296 | (86.3) * |
| Passing Sutures for Outside-in or Inside-out   | 287 | (83.7) * |
| Tying Knots                                    | 204 | (59.5) * |

### Knee Arthroscopy Critical Chondral Procedure Elements, n (%), N=343

| Procedure Type     | n   | (%)  |
|--------------------|-----|------|
| Microfracture      | 260 | (75.8) * |
| Chondroplasty      | 161 | (46.9) |

**TABLE 2: Critical steps of knee arthroscopy**

(*) signifies a critical element.
For ACL reconstruction, all steps were critical except preparing the footprints, closing, and positioning (Table 3). With regard to autograft harvesting during ACL reconstruction, identifying (65%) and stripping the hamstring tendons (69%), selecting the size of bone-patella-bone (BTB) graft (63%), and harvesting the BTB graft with a microsagittal saw (81%) were critical steps, but preparation of the graft on the back table was not (20%). Performing a notchplasty and debriding the ACL ligament were not considered critical steps. Regarding tunnel placement, identifying the proper location (95%), holding the drill guide (68%), and drilling the tunnels (61%) were critical steps. Lastly, the steps of graft fixation were all critical, except for cycling the graft. This included shutting the graft, determining the appropriate graft tension, and securing the graft with interference screws or aperture fixation.

| Overall ACL Reconstruction Critical Elements, n (%), N=343 |
|--------------------------------------------------------|
| Establishing Portals                                   | 180 (52.5) * |
| Graft Harvest                                          | 300 (87.5) * |
| Diagnostic Arthroscopy                                 | 179 (52.2) * |
| Debridement/Preparation of Footprints                  | 189 (55.1) * |
| Tunnel Placement                                       | 335 (97.7) * |
| Graft Fixation                                         | 316 (92.1) * |
| Closing Patella Tendon/Closure                         | 64 (18.7)    |
| None                                                   | 1 (0.3)      |
| Positioning                                            | 96 (28.0)    |

| ACL Reconstruction Critical Graft Harvest Elements, n (%), N=343 |
|---------------------------------------------------------------|
| Surgical Approach                                             | 166 (48.4)   |
| Identifying Hamstring Tendons                                 | 224 (65.3) * |
| Stripping Tendons with Tendon Stripper                       | 237 (69.1) * |
| BTB - Selecting Size of Patella Graft                        | 215 (62.7) * |
| BTB - Using Microsagittal Saw to Harvest Bone Plugs           | 277 (80.8) * |
| Preparing Graft on Back Table                                 | 67 (19.5)    |

| ACL Reconstruction Critical Debridement/Footprint Preparation Elements, n (%), N=343 |
|-------------------------------------------------------------------------------------|
| Notchplasty                                                                         | 142 (41.4)   |
| Debriding Footprints/ Removing ACL Stump                                           | 149 (43.4)   |

| ACL Reconstruction Critical Tunnel Placement Elements, n (%), N=343 |
|-------------------------------------------------------------------|
| Identifying Tunnel Position                                       | 324 (94.5) * |
| Holding Guide for Guide Pins                                     | 232 (67.6) * |
| Drilling Tunnels                                                  | 210 (61.2) * |
For rotator cuff repair, establishing portals (54%), preparing the footprint (64%), and repairing the tendon (94%) were critical. Positioning, diagnostic arthroscopy, subacromial bursectomy, and closure were found to be non-critical steps (Table 4). Further evaluation found that all aspects of repairing the tendon were critical, including identifying suture placement, passing sutures, identifying the number and location of anchors, determining single versus double row, and tying suture knots.
Rotator Cuff Repair Critical Footprint Preparation Elements, n (%), N=343

| Procedure                                      | Count (%) |
|------------------------------------------------|-----------|
| Using Shaver/Burr to Decorticate Humeral Footprint | 176 (51.3) * |
| Debriding Tendon Edges                         | 163 (47.5) |
| Tendon Mobilization                            | 215 (62.7) * |
| Marginal Convergence                            | 217 (63.3) * |
| Interval Slide                                  | 206 (60.1) * |

Rotator Cuff Repair Critical Tendon Repair Elements, n (%), N=343

| Procedure                                      | Count (%) |
|------------------------------------------------|-----------|
| Identifying Location of Suture Placement       | 298 (86.9) * |
| Passing Sutures with Suture Passer             | 261 (76.1) * |
| Passing Sutures with Suture Lasso              | 212 (61.8) * |
| Identifying Number of Anchors                  | 285 (83.1) * |
| Identifying Location of Anchors                | 306 (89.2) * |
| Determining Singer vs Double Row               | 274 (79.9) * |
| Tying Suture Knots                             | 258 (75.2) * |

| TABLE 4: Critical steps of rotator cuff repair |
| (* ) signifies a critical element. |

For arthroscopic anterior capsulorrhaphy with labral repair (or Bankart procedure), the critical elements were the establishment of portals (64%), glenoid preparation (80%), passing sutures (90%), and placing anchors (93%) (Table 5). Within glenoid preparation, both the mobilization of the labrum and decorticating the glenoid neck were critical. Passing sutures, the selection of the number and placement of anchors, drilling for anchors, and tying suture knots were all found to be critical. Similar to arthroscopic rotator cuff repair, diagnostic arthroscopy and closure were not critical.
### Overall Capsulorrhaphy, Anterior; with Labral Repair (i.e. Bankart Procedure) Critical Elements, n (%), N=343

| Procedure                                | n (%)   |
|-------------------------------------------|---------|
| Establishing Portals                      | 221 (64.4) * |
| Diagnostic Arthroscopy                    | 169 (49.3) |
| Preparing Glenoid                         | 274 (79.9) * |
| Passing Sutures                           | 309 (90.1) * |
| Placing Anchors                           | 320 (93.3) * |
| Closure                                   | 6 (1.7)  |
| Positioning                               | 107 (31.2) |

### Bankart Repair Critical Establishing Portals Elements, n (%), N=343

| Procedure                                | n (%)   |
|-------------------------------------------|---------|
| Portals in Lateral Decubitus Position     | 185 (53.9) * |
| Portals in Beach Chair Position           | 139 (40.5) |

### Bankart Repair Critical Glenoid Preparation Elements, n (%), N=343

| Procedure                                | n (%)   |
|-------------------------------------------|---------|
| Mobilizing Labrum                         | 271 (79.0) * |
| Decorticating Glenoid Neck                | 240 (70.0) * |

### Bankart Repair Critical Passing Sutures Elements, n (%), N=343

| Procedure                                | n (%)   |
|-------------------------------------------|---------|
| Passing Sutures at 3 o’clock Position     | 225 (65.6) * |
| Passing Sutures at 5-6 o’clock Position   | 307 (89.5) * |

### Bankart Repair Critical Placing Anchors Elements, n (%), N=343

| Procedure                                | n (%)   |
|-------------------------------------------|---------|
| Selecting Number of Anchors               | 276 (80.5) * |
| Selecting Location of Anchors             | 308 (89.8) * |
| Using Knotless Anchors                    | 226 (65.9) * |
| Using Traditional Anchors                 | 228 (66.5) * |
| Drilling Anchors                          | 274 (79.9) * |
| Tying Suture Knots                        | 255 (74.3) * |

**TABLE 5: Critical steps of anterior capsulorrhaphy with labral repair (Bankart procedure)**

(*) signifies a critical element.

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**Private versus academic**

For knee arthroscopy, private practice surgeons rated all aspects of knee arthroscopy except...
closure and positioning to be critical. Academic surgeons, on the other hand, did not find portal establishment (p<0.0001) or diagnostic arthroscopy (p<0.0001) to be critical. With regards to chondral procedures, private surgeons found chondroplasty to be a critical element while academic surgeons did not (p=0.007). For ACL reconstruction, private surgeons rated portal establishment (p<0.0001), diagnostic arthroscopy (p<0.0001), and debridement of footprint/ACL (p=0.012) to be critical while academic surgeons did not. For RCR, private surgeons rated portal establishment (p<0.0001), diagnostic arthroscopy (p<0.0001), and subacromial decompression (p=0.006) as critical steps while academic surgeons did not. For the Bankart procedure, private surgeons rated diagnostic arthroscopy (p<0.0001) and portal establishment (p<0.0001) as critical while academic surgeons did not (Table 6).

|                                | Academic | Private | P-value |
|--------------------------------|----------|---------|---------|
| Number of Responders           | 83       | 183     | -       |

### Overall ACL Reconstruction Critical Elements, n (%), N=266

|                                | Academic | Private | P-value |
|--------------------------------|----------|---------|---------|
| Establishing Portals           | 28 (33.7)| 121 (66.1)| <0.0001|
| Diagnostic Arthroscopy         | 28 (33.7)| 122 (66.7)| <0.0001|
| Debridement/Preparation of Footprints | 40 (48.2) | 118 (64.5) | 0.012   |
| Closing Patella Tendon/Closure | 4 (4.8)  | 44 (24.0) | <0.0001|
| Positioning                    | 17 (20.5)| 62 (33.9)| 0.027   |

### ACL Reconstruction Critical Graft Harvest Elements, n (%), N=266

|                                | Academic | Private | P-value |
|--------------------------------|----------|---------|---------|
| Surgical Approach              | 27 (32.5)| 110 (60.1)| <0.0001|

### ACL Reconstruction Critical Debridement/Footprint Preparation Elements, n (%), N=266

|                                | Academic | Private | P-value |
|--------------------------------|----------|---------|---------|
| Notchplasty                     | 28 (33.7)| 89 (48.6)| 0.023   |
| Debriding Footprints/ Removing ACL Stump | 31 (37.3) | 94 (51.4) | 0.034   |

### ACL Reconstruction Critical Tunnel Placement Elements, n (%), N=266

|                                | Academic | Private | P-value |
|--------------------------------|----------|---------|---------|
| Identifying Tunnel Position     | 75 (90.4)| 178 (97.3)| 0.027   |

### Overall Knee Arthroscopy Critical Elements, n (%), N=266

|                                | Academic | Private | P-value |
|--------------------------------|----------|---------|---------|
| Establishing Portals           | 20 (24.1)| 102 (55.7)| <0.0001|
| Diagnostic Arthroscopy         | 24 (28.9)| 109 (59.6)| <0.0001|

### Knee Arthroscopy Critical Establishing Portal Elements, n (%), N=266

|                                | Academic | Private | P-value |
|--------------------------------|----------|---------|---------|
| Anterior Portals               | 18 (21.7)| 96 (52.5)| <0.0001|
| Posterior Portals for Meniscal Root Repair | 18 (21.7) | 96 (52.5) | <0.0001|

### Knee Arthroscopy Critical Chondral Procedure Elements, n (%), N=266

|                                | Academic | Private | P-value |
|--------------------------------|----------|---------|---------|
| Chondroplasty                  | 31 (37.3)| 101 (55.2)| 0.007   |
| Overall Rotator Cuff Repair Critical Elements, n (%), N=266 |
|----------------------------------------------------------|
| Establishing Portals                                      |
|                                                          |
| Diagnostic Arthroscopy                                    |
|                                                          |
| Subacromial Bursectomy                                    |
|                                                          |
| Positioning                                               |
|                                                          |
| Rotator Cuff Repair Critical Establishing Portal Elements, n (%), N=266 |
| Portals in Lateral Decubitus Position                      |
|                                                          |
| Portals in Beach Chair Position                           |
|                                                          |
| Rotator Cuff Repair Critical Subacromial Bursectomy Elements, n (%), N=266 |
| Bursectomy                                                |
|                                                          |
| Acromioplasty                                             |
|                                                          |
| Tear Assessment                                           |
|                                                          |
| Rotator Cuff Repair Critical Footprint Preparation Elements, n (%), N=266 |
| Using Shaver/Burr to Decorticate Humeral Footprint         |
|                                                          |
| Debriding Tendon Edges                                    |
|                                                          |
| Overall Capsulorrhaphy, Anterior; with Labral Repair (i.e. Bankart Procedure) Critical Elements, n (%), N=266 |
| Establishing Portals                                      |
|                                                          |
| Diagnostic Arthroscopy                                    |
|                                                          |
| Bankart Repair Critical Establishing Portals Elements, n (%), N=266 |
| Portals in Lateral Decubitus Position                      |
|                                                          |
| Portals in Beach Chair Position                           |

TABLE 6: Differences according to setting (academic vs. private)

ACL - anterior cruciate ligament

(*) signifies a critical element.

Years in practice

Based on years of experience, surgeons with less experience (<15 years) did not rate portal establishment, diagnostic arthroscopy, or ligament debridement/notchplasty as critical ACL reconstruction steps while older surgeons did. Similar results were obtained for knee arthroscopy, with portal establishment and diagnostic arthroscopy regarded as non-critical by younger surgeons but critical by those with greater than 15 years of experience. Surgeons with less experience did not regard chondroplasty and meniscal debridement as critical, while the
more experienced surgeons did (p=0.032, p= 0.004, respectively). For RCR, experienced surgeons considered decorticating footprint (p= 0.38) and debriding tendon edges (p=0.183) to be critical while less experienced surgeons did not, however, the difference did not meet significance. All surgeons regardless of experience considered every aspect of the tendon repair (passing sutures, identifying the location of anchors, placing anchors, tying knots) to be critical. When comparing across surgeons for the Bankart procedure, closure and patient positioning were similarly regarded as non-critical aspects of the procedure. Younger surgeons, however, did not consider diagnostic arthroscopy to be critical (47% vs. 50%, p=0.535). Both cohorts regarded all sub-steps of this procedure to be critical and there were no differences between them.

**First assistant**

When comparing across years in practice, there was no difference in first assistant utilization. First assistants included residents, physician assistants (PAs), and nurse practitioners (NPs). Unlike surgeons with a resident as first assist, surgeons with a PA or NP found every step of each procedure to be critical except closure and positioning (Table 7). For all procedures, when a resident was first assistant, positioning, portal establishment, diagnostic arthroscopy, and closure were not found to be critical. For ACL reconstruction, when a resident was the first assistant, the only critical steps were graft harvest, tunnel placement, and graft fixation. For knee arthroscopy, chondroplasty was not found to be critical when a resident was first assistant. For RCR, tendon repair was the only critical step.

| Number of Responders | Resident First Assist | PA/NP | P-value |
|----------------------|----------------------|-------|---------|
| Overall ACL Reconstruction Critical Elements, n (%), N=343 | 102 | 169 | - |
| Establishing Portals | 33 (32.4) | 105 (61.8) | <0.0001 |
| Diagnostic Arthroscopy | 30 (29.4) | 110 (64.7) | <0.0001 |
| Debridement/Preparation of Footprints | 39 (38.2) | 110 (64.7) | <0.0001 |
| Closing Patella Tendon/Closure | 6 (5.9) | 35 (20.6) | 0.001 |

| Number of Responders | Resident First Assist | PA/NP | P-value |
|----------------------|----------------------|-------|---------|
| Overall Knee Arthroscopy Critical Elements, n (%), N=272 | | | |
| Establishing Portals | 25 (24.5) | 93 (54.7) | <0.0001 |
| Diagnostic Arthroscopy | 28 (27.5) | 103 (60.6) | <0.0001 |
| Procedure                                           | Count (Percentage) | Count (Percentage) | p-Value |
|-----------------------------------------------------|--------------------|--------------------|---------|
| Meniscal Debridement                                 | 60 (58.8)          | 124 (72.9)         | 0.016   |
| Positioning                                          | 6 (5.9)            | 23 (13.5)          | 0.048   |
| **Knee Arthroscopy Critical Establishing Portal Elements**, N=272 |                    |                    |         |
| Anterior Portals                                     | 20 (19.6)          | 87 (51.2)          | <0.0001 |
| Posterior Portals for Meniscal Root Repair           | 21 (20.6)          | 87 (51.2)          | <0.0001 |
| **Knee Arthroscopy Critical Meniscal Debridement Elements**, N=272 |                    |                    |         |
| Identifying which Tears Need Menisectomy vs Repair    | 56 (54.9)          | 122 (71.8)         | 0.005   |
| Identifying Amount of Meniscal Debridement           | 58 (56.9)          | 119 (70.0)         | 0.028   |
| Performing Meniscectomy with Shaver and/or Biter      | 41 (40.2)          | 103 (60.6)         | 0.001   |
| **Knee Arthroscopy Critical Meniscal Repair Elements**, N=272 |                    |                    |         |
| Establishing Technique (All inside/Outside In/ Inside Out) | 77 (75.5)          | 148 (87.1)         | 0.015   |
| Approach if using Outside In/ Inside Out              | 75 (73.5)          | 143 (84.1)         | 0.034   |
| Tying Knots                                          | 54 (52.9)          | 111 (65.3)         | 0.043   |
| **Knee Arthroscopy Critical Chondral Procedure Elements**, N=272 |                    |                    |         |
| Chondroplasty                                        | 35 (34.3)          | 92 (54.1)          | 0.002   |
| **Overall Rotator Cuff Repair Critical Elements**, N=272 |                    |                    |         |
| Establishing Portals                                  | 31 (30.4)          | 110 (64.7)         | <0.0001 |
| Diagnostic Arthroscopy                               | 27 (26.5)          | 108 (63.5)         | <0.0001 |
| Subacromial Bursectomy                                | 28 (27.5)          | 91 (53.5)          | <0.0001 |
| Preparing Footprint                                  | 57 (55.9)          | 118 (69.4)         | 0.024   |
| **Rotator Cuff Repair Critical Establishing Portal Elements**, N=272 |                    |                    |         |
| Portals in Lateral Decubitus Position                 | 23 (22.5)          | 92 (54.1)          | <0.0001 |
| Portals in Beach Chair Position                      | 22 (21.6)          | 79 (46.5)          | <0.0001 |
| **Rotator Cuff Repair Critical Subacromial Bursectomy Elements**, N=272 |                    |                    |         |
| Bursectomy                                           | 18 (17.6)          | 83 (48.8)          | <0.0001 |
| Acromioplasty                                        | 23 (22.5)          | 90 (52.9)          | <0.0001 |
| Tear Assessment                                      | 28 (27.5)          | 89 (52.4)          | <0.0001 |
| **Rotator Cuff Repair Critical Footprint Preparation Elements**, N=272 |                    |                    |         |
| Using Shaver/Burr to Decorticate Humeral Footprint    | 39 (38.2)          | 98 (57.6)          | 0.002   |
| Debridging Tendon Edges                              | 36 (35.3)          | 90 (52.9)          | 0.005   |
| Tendong Mobilization                                 | 55 (53.9)          | 115 (67.6)         | 0.024   |
### Table 7: Differences according to first assistant

| Procedure                                                                 | PA   | NP   | p-value |
|---------------------------------------------------------------------------|------|------|---------|
| Marginal Convergence                                                      | 55 (53.9) | 116 (68.2) | 0.018 |
| Interval Slide                                                            | 51 (50.0) | 112 (65.9) | 0.01  |
| Rotator Cuff Repair Critical Tendon Repair Elements, n (%), N=272         |      |      |         |
| Identifying Location of Suture Placement                                  | 84 (82.4) | 154 (90.6) | 0.047 |
| Identifying Location of Anchors                                          | 88 (86.3) | 160 (94.1) | 0.027 |
| Overall Capsulorrhaphy, Anterior; with Labral Repair (i.e. Bankart Procedure) Critical Elements, n (%), N=272 |      |      |         |
| Establishing Portals                                                      | 50 (49.0) | 124 (72.9) | <0.0001 |
| Diagnostic Arthroscopy                                                    | 26 (25.5) | 108 (63.5) | <0.0001 |
| Bankart Repair Critical Establishing Portals Elements, n (%), N=272       |      |      |         |
| Portals in Lateral Decubitus Position                                     | 37 (36.3) | 108 (63.5) | <0.0001 |
| Portals in Beach Chair Position                                           | 31 (30.4) | 77 (45.3) | 0.015 |
| Bankart Repair Critical Glenoid Preparation Elements, n (%), N=272        |      |      |         |
| Decorticating Glenoid Neck                                                | 64 (62.7) | 128 (75.3) | 0.028 |

**Discussion**

Every surgical procedure is a series of steps, some more critical than others. Some steps of a procedure are so important that any misstep or lack of guidance may expose the patient to undue harm. Despite their crucial role in surgical training, billing and the ethicality of concurrent surgery, the “critical steps” of arthroscopy procedures have not yet been clearly defined and interpretation has fallen in the hands of the surgeon. The current study aims to reach a greater consensus of which steps are generally deemed critical by surgeons and to identify how this may vary according to certain demographic parameters. The elucidation of critical elements for surgical procedures has potential ramifications on surgical education, concurrent surgery, surgical billing, and medical ethics.

Recent press reports have suggested that there is an increase in adverse patient outcomes and longer procedure times when an attending surgeon is operating in two different surgical suites [1]. The concept of concurrent surgeries in orthopedic literature is limited; however, a recent analysis of overlapping surgery in the ambulatory setting has been described. Zhang et al. performed a retrospective review over a three-year period and found that 68% of cases were concurrent while 32% were not [6]. They found no difference in the postoperative complication rate between the cohorts (1.1% vs. 1.3%, p=0.811). They also concluded that overlapping surgery yields an equivalent operating time in an ambulatory setting [6]. National registry data from the American College of Surgeons in greater than 20,000 knee and shoulder arthroscopic cases has shown these procedures to be inherently safe, with a 30-day complication rate of 1.6% and 0.99%, respectively [7-8].
We report that for the most common arthroscopic sports medicine surgeries, there was considerable variability in the elements deemed "critical" by the surveyed respondents. Patient positioning and closure were not deemed critical steps among all procedures. Diagnostic arthroscopy was only critical when performing ACL reconstruction. Interestingly, the establishment of arthroscopic portals was viewed as critical for all procedures except knee arthroscopy.

We found significant differences between academic and private practice surgeons, suggesting that the notion of "critical element" may be influenced by the surgical setting. Notably, nearly all steps in all four procedures were considered critical by private practice surgeons. Often, surgeons practicing in a private setting lack highly trained surgical assistants, such as residents and fellows, who are qualified and capable of performing a number of operative steps independently. As a result, nearly every step of a surgical procedure in a private practice requires the direct supervision of the surgeon.

Younger surgeons, defined as those with less than 15 years of practice, were significantly less likely to consider diagnostic arthroscopy and portal establishment as critical steps of the procedure. The difference is likely, in part, due to a comfort level with arthroscopy cases since nearly 98% of the younger respondents had completed a sports medicine fellowship compared to only 82% of the more experienced surgeons (p<0.01).

Although completely novel in the sports medicine literature, there are limitations to the current study. First, the study is limited by the response rate. The survey was distributed to over 2,000 surgeons; however, only 17% responded to the survey. One reason for an imperfect response rate may be that there is no way of identifying how many surgeons received the email. Some of these emails may have been processed as spam or the email listed is not the primary email used by the surgeon. Overall, establishing a consensus regarding the "critical" elements of surgery may necessitate a more robust sample size. Lastly, a potential limitation is that there are likely other factors that influence how surgeons classify different steps of surgery. Patient characteristics, including body weight, comorbid conditions, anatomic variations, and prior arthroscopic procedures, may significantly influence a surgeon’s perception of the surgical procedure.

Conclusions

The notion of "critical" is used colloquially by the medical community in the form of national guidelines, consent forms, and reimbursement regulations. Until now, there have not been any attempts to define critical steps of arthroscopic sports medicine procedures. For four of the most common arthroscopic sports medicine procedures, elements that were not regarded as critical routinely included positioning, the establishment of portals, and closure. However, given the variability based on surgical subspecialty, surgical setting, and surgeon experience, it is difficult to reach a general consensus and standardized definitions of "critical" elements should be established by professional sports medicine societies.

Additional Information

Disclosures

Human subjects: Consent was obtained by all participants in this study. Animal subjects: All authors have confirmed that this study did not involve animal subjects or tissue. Conflicts of interest: In compliance with the ICMJE uniform disclosure form, all authors declare the following: Payment/services info: All authors have declared that no financial support was received from any organization for the submitted work. Financial relationships: All authors have declared that they have no financial relationships at present or within the previous three
years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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