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Predictors of Dislocation and Revision After Shoulder Stabilization in Ontario, Canada, From 2003 to 2008

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Background: Factors contributing to recurrent dislocation, revision stabilization, and complications requiring reoperation after an initial shoulder stabilization procedure for instability have not been evaluated on a population level.

Purpose: (1) To define the rate of ipsilateral revision stabilization, contralateral primary stabilization, postoperative dislocation, and complications after primary shoulder stabilization in a population cohort. (2) To understand which risk factors among patient, surgical, and provider factors influence these outcomes.

Study Design: Cohort study; Level of evidence, 3.

Methods: All residents of Ontario, Canada, aged 16 to 60 years undergoing primary shoulder stabilization between July 2003 and December 2008 were identified from billing and hospital databases. Separate Cox proportional hazards survivorship models were built for the outcomes revision stabilization and postoperative physician-documented shoulder relocation (minimum 2-year follow-up). Model covariates included patient demographics (age, sex, preoperative dislocations), provider characteristics (surgeon volume, hospital academic status), and type of surgery (open, arthroscopic). The frequency and risk factors for contralateral stabilization were identified.

Results: A total of 5904 patients (80.6% male; median age, 29 years) were identified. Arthroscopic stabilization was used in ~60% of cases in 2003, increasing to ~80% in 2008. The rates of postoperative dislocation were 6.9%, revision stabilization 4%, and contralateral primary stabilization 3.9%. Patients aged younger than 20 years had a 7.7% revision rate (hazard ratio [HR], 2.7; 95% confidence interval [CI], 1.7-4.2; $P < .0001$) and a 12.6% rate of postoperative physician-documented dislocation (HR, 2.4; 95% CI, 1.8-3.4; $P < .0001$), compared with 2.8% and 5.5%, respectively, in patients 29 years old (median cohort age). Patients with 3 or more preoperative dislocations in Ontario had an increased risk of revision (HR, 2.1; 95% CI, 1.5-3.0; $P < .0001$) and postoperative dislocation (HR, 10.6; 95% CI, 8.1-14.0; $P < .0001$). Revision was more common after arthroscopic (4.3%) compared with open (3.5%) stabilization (HR, 1.4; 95% CI, 1.02-1.98; $P = .04$). No provider factor was predictive, including surgeon volume. Reoperation rate for complications not related to recurrent instability was 0.23% (infection, 0.07%; manipulation under anesthesia, 0.15%).

Conclusion: The risks of revision stabilization and postoperative (either shoulder) dislocation were most influenced by young age (<20 years) and having had 3 or more preoperative dislocations. Complications requiring surgery are rare.

Keywords: shoulder instability; Bankart; shoulder dislocation; revision

Traumatic anterior shoulder dislocation leading to instability is a common orthopaedic condition. In 85% or more of patients, an anterior dislocation is associated with a tear of the anterior-inferior labrum, with or without a bony fragment.[2] Recurrent instability, defined by ongoing symptomatic subluxation or dislocation of the glenohumeral joint, is considered an indication for surgical stabilization.[3]

Many surgical procedures have been described to correct anterior instability, including nonanatomic repairs and those that aim to restore native anatomic features. The most common modern treatment involves repair of the torn labrum and associated inferior glenohumeral ligament, by either open or arthroscopic techniques.[3] Additionally, many surgeons now address capsular redundancy surgically, after a cadaver study demonstrated that a dislocation could not occur without tearing or stretching of the joint capsule.[32]

Both open and arthroscopic repairs for recurrent anterior instability have shown largely good results, although some debate exists as to the indications for each approach and their relative success rates.[23] Arthroscopic repair has been touted as less invasive, by being muscle sparing, and associated with both reduced blood loss and postoperative pain compared with open repair.[13]

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Although 4 prospective randomized trials did not show a significant difference in failure rates between open and arthroscopic stabilization, meta-analyses of level 3 and 4 studies favor open repair.[6,12,16,23,26] The rates of reported failure after shoulder stabilization surgery from studies included in these meta-analyses range between 1.1% and 11.5% for reoperation and between 0.95% and 17.4% for postoperative dislocation.[23] The true general population failure rates are unknown.

Another potential modifier of reoperation after shoulder stabilization is surgeon volume. Population data for some elective orthopaedic procedures have demonstrated higher morbidity when procedures are performed by lower volume surgeons (Lyman et al[24]) and higher revision rates in the case of total knee,[15] total hip,[21] and total shoulder[19] replacement. The influence of provider volume on reoperation after shoulder stabilization has never been evaluated.

Current, published data typically represent outcomes from specialized centers or from case series with significant selection bias. Our goal was to better understand the rates, time frame, and prognostic factors influencing revision stabilization surgery and postoperative shoulder dislocation after a primary stabilization procedure performed either open or arthroscopically in Ontario. The secondary goal was to examine practice patterns of surgical stabilization with respect to the use of arthroscopy and to characterize the rates of reoperation for non–instability related complications.

MATERIALS AND METHODS

This study was performed using anonymous Ontario provincial administrative health records held by the Institute for Clinical Evaluative Sciences (ICES; www.ices.on.ca). Ontario Health Insurance Plan (OHIP) fee codes were used to identify all patients who underwent surgical stabilization of the shoulder in the Province of Ontario between July 1, 2003, and December 31, 2008 (for relevant fee codes see Appendix Table S1, available online at http://ajsm.sagepub.com/supplemental). The OHIP provides universal health care coverage, and the OHIP fee code and demographic data have been demonstrated to be highly accurate on independent chart review.[35] Patient records were followed for postoperative outcomes of interest for a minimum of 2 years after surgery (until February 28, 2011; see Appendix Table S2).

Demographic data were obtained from the Registered Persons Database (RPD), associated with OHIP, of every person granted an Ontario health card.

Entry to the cohort also required an associated elective hospital admission record. Anonymous patient identification numbers were used to link each patient's data held at the provincial level (ie, OHIP) to the Canadian Institutes for Health Information (CIHI) national databases. Specifically, data were obtained from CIHI's Same Day Surgery (SDS) and Discharge Abstract Database (DAD) and included relevant diagnostic codes from the *International Classification of Diseases, 10th Revision* (*ICD-10*; see Appendix Table S3) to assist in the refinement of this cohort. Independent chart review has demonstrated a high accuracy (positive predictive value >95%) of *ICD-10* coding within SDS/DAD for orthopaedic conditions,[28] although shoulder instability has not been specifically examined.

Exclusion criteria were based on clinically relevant factors identified by either additional OHIP fee codes, demographic data, or *ICD-10* coding. Only adult patients between 16 and 60 years were included. Patients who were not Ontario residents at the OHIP fee code service date were excluded on the basis of poor expected follow-up. Patients in whom 2 OHIP fee codes were found for shoulder stabilization in the same admission were excluded on the basis of a billing anomaly or potentially bilateral surgery. An OHIP fee code specific for revision shoulder surgery, prior stabilization, or presumed bony procedure resulted in exclusion (see Appendix Table S1). Patients whose index event also contained OHIP fee codes for proximal humeral fractures (ie, fracture-dislocations) were excluded. The *ICD-10* coding for inferior or posterior shoulder dislocation was another exclusion criterion (Table 1).

Main Outcome

Two main outcomes were considered. The first was revision shoulder stabilization defined by a specific OHIP fee code for revision stabilization (E058). The second was an OHIP fee code for closed shoulder relocation, representing a physician-documented dislocation, as performed in an operating room or emergency room setting within Ontario. Dislocations that occurred outside Ontario, or did not require physician relocation, and revision stabilizations that took place outside Ontario were beyond the capture of this study.

Laterality was not determined for any main outcome or the index event. Revisions were confirmed by OHIP fee code only. Primary stabilization billing codes submitted on a cohort patient during the follow-up period were presumed to pertain to the contralateral side. Differentiation between contralateral and ipsilateral (postoperative) shoulder relocation, however, was not confirmed. The

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TABLE 1
Inclusion and Exclusion Criteria for the Primary Stabilization Cohort[a]

	No.
Inclusion criterion	
OHIP fee code (#R401) match with DAD/SDS	6388
Exclusion criteria	
Age <16 or >60 y	179
Non-Ontario residents	6
Revision or bony procedure specified at index event, or prior R401	269
Two OHIP fee codes from same surgeon, same date	9
Fracture associated with index event	10
Inferior or posterior shoulder dislocation from *ICD-10* coding	1
Incomplete demographic data	10
Cohort size after exclusions	5904

[a]DAD, Discharge Abstract Database; *ICD-10, International Classification of Diseases, 10th Revision*; OHIP, Ontario Health Insurance Plan; SDS, Same Day Surgery.

CIHI records do contain procedural codes (eg, for shoulder relocation) that specify laterality; however, this record is often inadequate (specified in ≤50% of cases), and therefore we elected not to use it.

Covariates

Surgeon volume was calculated by anonymous surgeon identification followed by a 1 (calendar) year review of the number of stabilization codes billed by that surgeon. Based on the distribution of surgeon volumes and perceived clinical significance, surgeons were categorized as low (0-11 procedures per year), medium (12-36 per year), or high (37+ per year) volume. The highest volume for a single surgeon was 78 procedures per year.

The SDS/DAD records indicated the hospital in which the index surgery took place. Hospitals were assigned "academic" (ie, teaching) or "nonacademic" status based on membership in the Council of Academic Hospitals of Ontario. Specific hospital identification in data analysis is prohibited by ICES privacy policies.

Patient age was divided into categories of 5-year blocks, and patient sex was specified. Patient income quintile was estimated by home postal code using an established method.[5] Income quintile was considered a surrogate for socioeconomic status.

Patient comorbidity was estimated using the adjusted clinical group (ACG) method.[20] Each patient was assigned to any number of 12 collapsed aggregate diagnosis groups (CADGs), defined by constellations of conditions of similar severity and chronicity based on coding from the *ICD-10* from all databases using a 2-year review period (see Appendix Table S4).[1]

The number of physician-documented dislocations before the index surgical date was considered for each patient and defined by the number of OHIP fee codes for shoulder relocation (open or closed) in the preceding 10 years. Patients were categorized as having 0, 1, 2, or 3+ prior dislocations. Information regarding undocumented dislocations and those occurring outside Ontario was not available. Laterality was not determined. The use of arthroscopy with the index event was identified via OHIP fee code.

Secondary Outcomes

Reoperation within 2 years of the index procedure date was sought for manipulation of the shoulder under anesthesia as a potential surrogate for stiffness. Surgical irrigation and debridement of the shoulder identified by OHIP fee code was considered a surrogate for deep infection (see Appendix Table S2, available online). The same covariates were modeled.

Statistical Analysis

Two main statistical approaches were used. Secondary outcomes were analyzed using logistic regression modeling. Odds ratios with 95% confidence intervals (CIs) and associated *P* values were calculated.

In contrast, the main outcomes were analyzed over the entire data collection period using survivorship analysis that generated Kaplan-Meier survival curves. Censorship was considered with death, a positive main outcome, or a loss of OHIP coverage. A Cox proportional hazards model was used to evaluate the effect of covariates on the main outcome[33] with the calculation of hazard ratios (HRs) and associated 95% CIs. All reported *P* values are 2-tailed with an α of .05. The effect of multiple comparisons was considered in the interpretation of the results, but a multiple comparison correction was not applied because no covariate was considered time dependent.[11] Analyses were performed at the Institute for Clinical Evaluative Sciences using SAS version 9.1 for UNIX (SAS Institute, Cary, North Carolina). The research protocol was approved by the Research Ethics Board at Sunnybrook Health Sciences Centre, Toronto, Ontario (through ICES).

RESULTS

An initial database search yielded 6388 patients. Application of exclusion criteria resulted in a final cohort size of 5904, with an additional 10 patients (0.17%) excluded on the basis of incomplete demographic data (Table 1).

The median cohort age was 29 years (interquartile range [IQR], 20-37 years). The majority of patients were male (80.6%). Arthroscopy was performed in 68.9% of cases. The distribution of cases by age category is shown in Figure 1, with a peak in the 16- to 20-year age group and a decreasing frequency at each interval thereafter. The mean time to revision stabilization was 2.2 ± 1.3 years. The mean time to postoperative relocation was 2.0 ± 1.4 years. Overall, the rate of revision stabilization was 4.1% and the rate of postoperative relocation was 6.9%. The rate of a contralateral shoulder stabilization procedure was 3.9%. The minimum follow-up was 2 years (median, 4.5 years). The 5-year Kaplan-Meier survivorship estimation for revision stabilization was 95.7% (Figure 2) and for postoperative physician relocation 92.6% (Figure 3).

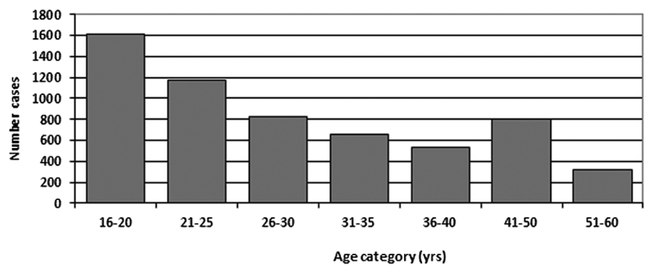


Figure 1. The distribution of index cases by age category.

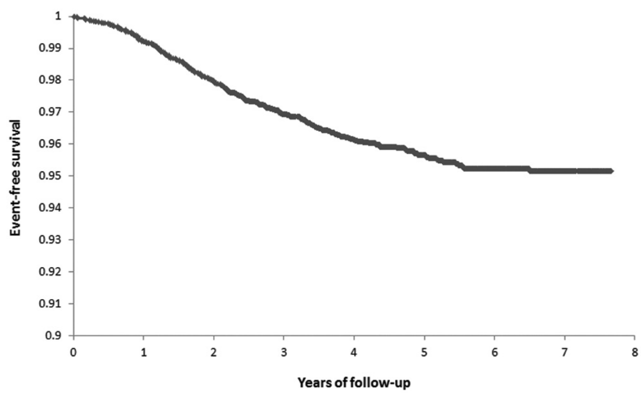


Figure 2. Kaplan-Meier survival curve to revision stabilization.

The use of arthroscopy for stabilization surgery increased over time. In 2003 approximately 60% of surgeons used arthroscopy, and this rate increased to almost 80% by 2008 (Figure 4).

Manipulation of the shoulder for presumed stiffness and irrigation and debridement of the shoulder for presumed infection were rare events, occurring after only 9 (0.15%) and 4 (0.07%) cases, respectively. No identifiable risk factor from the regression analysis was identified for subsequent shoulder irrigation and debridement. Two occurred after arthroscopic surgery (2/4802; 0.04%) and 2 after open surgery (2/1102; 0.18%); this difference was not statistically significant (P = .67). The rate of subsequent shoulder joint manipulation under anesthesia (MUA) was 0.15%. Six of the 9 patients who underwent MUA were female (0.5%) compared with 3 male (0.06%) patients (HR, 6.9; 95% CI, 2.1-23.3; P = .002).

The Cox proportional hazards modeling for both revision stabilization and postoperative Ontario physician relocation yielded similar results. Both age and the number of prior documented (in Ontario) physician relocations were important risk factors. The age category containing the mean and median cohort age (26-30 years) was used as the reference value in the analysis, as was zero prior documented relocations. Only patients aged 16 to 20 years had a statistically significant difference in the risk of revision compared with a person of median age (Figure 5). This corresponded to a 7.7% revision rate in patients younger than 20 compared with 2.8% for patients aged 26 to 30 years.

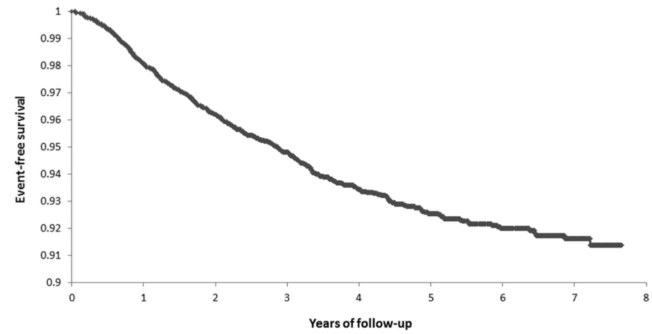


Figure 3. Kaplan-Meier survival curve to postoperative physician relocation.

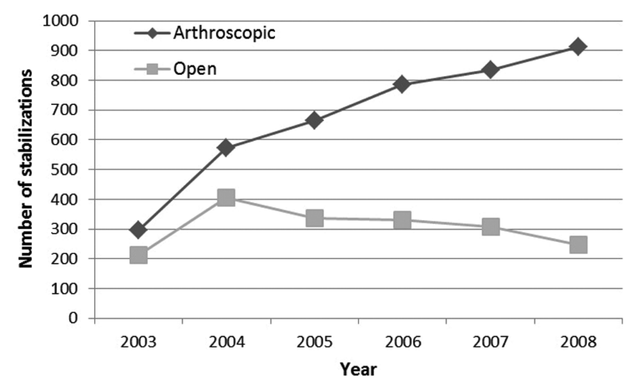
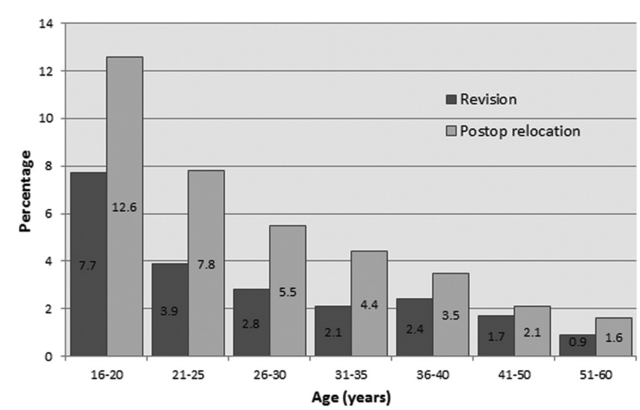


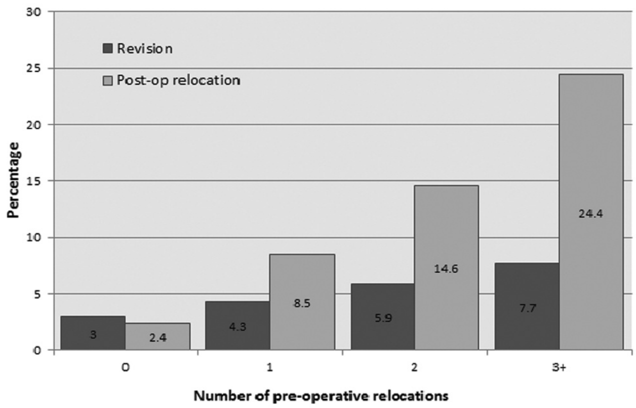
Figure 4. Trends in stabilization technique (open and arthroscopic) by year. Only partial data for 2003 are available, as information was collected from July onward.



	Age category*	Hazard Ratio	p-value
Revision	16-20	2.7 (1.7, 4.3)	<0.0001
Post-op relocation	16-20	2.4 (1.8, 3.4)	<0.0001

*Reference group was age category = "26-30 years"

Figure 5. The percentage of patients by age category who underwent revision stabilization surgery and postoperative physician-documented relocation.



	Prior dislocations	Hazard Ratio	P-value
Revision*	3+	2.1 (1.5, 3.0)	<0.0001
Post-op relocation*	1	3.3 (2.5, 4.6)	<0.0001
	2	5.9 (4.2, 8.0)	<0.0001
	3+	10.7 (8.1, 14.0)	<0.0001

*Reference group was "0" prior

Figure 6. Rates of revision stabilization and postoperative relocation by number of Ontario physician–documented dislocations prior to the index event.

Patients who had 3 or more Ontario physician–documented dislocations before their stabilization surgery were at significantly increased risk of requiring revision stabilization. The rate of revision was 7.7% in patients with 3+ prior relocations, compared with 3% in those with none (HR, 2.1; 95% CI, 1.5-3.0; $P < .0001$) (Figure 6). Patients with 1 or 2 prior documented relocations had no significant change in their risk of revision stabilization.

The use of arthroscopy with surgery carried a slightly increased risk of revision surgery (HR, 1.4; 95% CI, 1.02-1.98; $P = .04$) with a rate of revision (4.3%) compared with surgery performed open (3.5%).

The risk of postoperative dislocation identified via OHIP fee code was substantially increased based on patient age and the number of documented prior dislocations. Only patients younger than 20 years of age were at increased risk. The rate of postoperative dislocation in this age group was 12.6% compared with 5.5% for the cohort median age (HR, 2.4; 95% CI, 1.8-3.4; $P < .0001$). However, the rate of postoperative dislocations significantly increased with any number of preoperative dislocations, in comparison with patients without a prior documented relocation. Patients who had 3 or more preoperative relocations had a postoperative dislocation rate of 24.4% compared with 2.4% for patients who had none (HR, 10.7; 95% CI, 8.1-14.0; $P < .0001$) (Figure 6).

No provider factor such as surgeon volume ($P = .56$) or hospital status ($P = .58$) or patient factors such as sex ($P = .78$) or income quintile ($P = .55$) influenced either main outcome.

There was a trend toward increased rates of contralateral shoulder stabilization surgery in the follow-up period on the basis of the number of preoperative relocations (Table 2). This trend did not approach statistical significance in the Cox proportional hazards modeling, except for patients with 3 or more previously documented dislocations. Patients with a younger age at index stabilization were at increased risk of undergoing contralateral stabilization, while those over age 40 years were significantly less likely to undergo contralateral stabilization. Male patients were more likely than females to undergo contralateral stabilization.

TABLE 2
Contralateral Shoulder Stabilization Rates by Age and Number of Preoperative Dislocations[a]

Covariate	Rate, %	Hazard Ratio (Confidence Interval)	*P* Value
Preoperative relocations, No.			
0	3.4	Reference group	
1	4.6	1.3 (0.9-1.8)	.14
2	3.6	0.97 (0.6-1.6)	.90
3+	**5.7**	**1.6 (1.1-2.3)**	**.02**
Age, y			
16-20	**6.3**	**1.8 (1.2-2.7)**	**.0069**
26-30	3.9	Reference group	
41-50	**1.7**	**0.4 (0.2-0.8)**	**.0075**
51-60	**1.2**	**0.3 (0.09-0.8)**	**.016**
Sex			
Male	4.1	Reference group	
Female	**3.0**	**0.63 (0.43-0.93)**	**.02**

[a]Boldface data refer to statistically significant factors ($P < .05$).

DISCUSSION

The most important finding of this study is that both younger patient age and increased numbers of documented preoperative physician relocations increase the likelihood of poorer outcomes—namely revision stabilization and postoperative shoulder dislocation. Overall, in this population study, the revision rates for open and arthroscopic stabilization are reasonably low, at 3.5% and 4.3%, respectively. This difference achieved borderline statistical significance ($P = .04$) and should be interpreted cautiously in light of multiple comparisons.

The association in the literature between young patient age at first dislocation and likelihood of recurrent dislocation is well documented.[17] However, the relationship between younger patient age and increased risk of revision stabilization is less well understood, with this association reported in only a few previous studies.[14,18] A recent series of 73 patients undergoing arthroscopic Bankart repairs identified those under age 25 as at increased risk of failure.[34]

The risk of postoperative dislocation was substantially increased based on the number of documented prior dislocations; patients who had 3 or more preoperative relocations had a postoperative relocation rate of 24.4% compared with 2.4% for patients who had none. There is some support in the literature for our findings of a positive association between number of dislocations before surgery and dislocations after surgery.[18] It is not uncommon for patients to report recurrent subluxation or dislocation with spontaneous shoulder reduction, rather than physician-documented dislocation, but this unfortunately was not captured by these data. Nevertheless, it seems plausible that shoulder dislocations requiring physician relocation are more likely to have significant pathologic lesions, whether it be soft tissue (capsular and labral) or bony structures (Hill-Sachs and glenoid defects), potentially increasing the risk of failure of stabilization surgery. Our results corroborate this assertion, as patients without a documented preoperative physician relocation had the lowest rate of revision and postoperative dislocation rates.

The progressive risk of poorer outcomes from primary stabilization with each subsequent dislocation is compelling and may support early shoulder stabilization, especially in patients with other risk factors (eg, younger age). There exists literature supporting stabilization for first-time dislocation over nonoperative measures,[8] citing a reduction in the risk of subsequent dislocation. Our study has identified that outcomes including postoperative dislocation and revision rates might be improved in these patients rather than those with multiple dislocations. However, we acknowledge that preoperative dislocations may have occurred on the contralateral (unoperated) side, and therefore we caution here the interpretation of a specific threshold number of preoperative dislocations. Furthermore, the effect of prior subluxations, spontaneous shoulder reductions, and preoperative dislocations treated outside of Ontario on the risk of subsequent revision in this cohort is beyond the scope of these data.

The slope of the Kaplan-Meier curve for revision stabilization plateaued around the 5-year postoperative mark, suggesting that the likelihood of revision after 5 years is quite low. In this study, 2511 of the 5904 patients were still at risk for revision at 5 years (not censored in the analysis)—a sizeable long-term cohort. Similarly, at 2-year follow-up, the rate of dislocation was 3.8% compared with 6.9% overall. This information suggests that any shoulder stabilization study with only 2-year follow-up should be interpreted with caution.

This study has reported on a large scale the reoperation morbidity after primary shoulder stabilization. This morbidity was extremely low, with a postoperative joint washout rate of only 0.07% and MUA of 0.15%. Female sex was a risk factor for subsequent manipulation; however, the number of cases (n = 6) was extremely small. These conclusions need to be interpreted with some caution for 2 reasons. First, some surgeons may have performed an arthroscopic lysis of adhesions only (for which there is no specific OHIP fee code to capture this event). Second, it is possible that both the MUA and joint washout were performed on the contralateral shoulder for unrelated indications such as frozen shoulder or septic arthritis. Nevertheless, these results demonstrate that the rate of these complications is very low.

We identified that arthroscopic shoulder stabilization made up an increasing proportion of primary stabilizations over time, a finding supported in the literature. Owens et al[27] tracked the trends of Bankart repair among newly certified surgeons submitting cases to the American Board of Orthopaedic Surgery part 2 examination. The investigators found that 71.2% of repairs were performed arthroscopically between 2003 and 2005, which increased to 87.7% between 2006 and 2008. Although this trend is similar, our data showed a slightly lower proportion of arthroscopic repairs overall, possibly reflecting minor differences related to national practice or attributable to that fact that our data included all Ontario surgeons and not just those new to practice. The finding of increased operative volume overall is interesting and needs to be explored in the context of changing trends in the incidence of instability.

The primary event in this study was surgical stabilization defined as "repair, recurrent dislocation." Realistically, such a description encompasses a wide variation of repair techniques beyond simply open versus arthroscopic repair. Both open and arthroscopic shoulder stabilization techniques may vary from patient to patient, depending on factors such as capsular laxity identified intraoperatively.[31,22] In an attempt to focus on soft tissue repair only, patients with a concurrent billing code for a bony procedure were excluded. Furthermore, there are variations in fixation methods of labral and capsular tissue, potentially leading to discrepancies in outcome; for example, open and arthroscopic repairs appear to be equally efficacious only when performed with suture anchors.[16,29] The data available on fixation type did not allow a detailed analysis in this population.

Other potential prognostic variables beyond the scope of this database study included extent of bone loss,[4,10,14,34] ligamentous laxity,[4,7,34] and activity level/sport type.[9,25,30] Although we assume that surgeons are performing soft tissue stabilization procedures on patients with no or minimal bony component to their condition, this may not be the case in practice. Another limitation relates to our findings for the number of dislocations both pre- and postoperatively—this data set did not allow confirmation that shoulder reductions were performed on the same side as the index surgery. Some relocations must represent the contralateral side, and therefore we have overestimated the number of dislocations in this cohort to an unknown degree. Furthermore, episodes of subclinical instability (ie, subluxation) and episodes of patients reducing their own shoulder dislocations were not available due to the nature of this study; thus, the incidence of recurrent instability will tend to be underestimated. Finally, no data are available regarding the subjective outcomes of patients or their quality of life.

Although chart abstraction studies have validated the accuracy of diagnostic and OHIP fee codes,[35] some inaccuracies are to be expected, and this remains a limitation of this study. A related limitation of database studies is loss-to-follow-up. By censoring patients who subsequently lost OHIP coverage because of emigration or other reasons during the follow-up period of this cohort, we have limited this influence. Baseline rates of revision could still be influenced by those who emigrated, but survivorship would not. Some remaining (OHIP-insured) patients, however, may have electively pursued revision stabilization surgery in another jurisdiction or may have suffered a shoulder dislocation while out of Ontario.

This study is important as the largest prognostic study to evaluate shoulder stabilization surgery. We have confirmed that patients under 20 years of age are at significantly increased risk of revision surgery and postoperative dislocation compared with older patients, as are those with 3 or more preoperative dislocations requiring a formal reduction. Patients should be counseled with this knowledge. Finally, the comparative rates of revision after arthroscopic and open stabilization and the time frame to revision stabilization provide critical pieces of information for the effective design of high-level prospective trials still needed to answer key clinical questions.

REFERENCES

1. Baldwin LM, Klabunde CN, Green P, Barlow W, Wright G. In search of the perfect comorbidity measure for use with administrative claims data: does it exist? *Med Care*. 2006;44(8):745-753.
2. Bankart AS, Cantab MC. Recurrent or habitual dislocation of the shoulder joint. *Clin Orthop Relat Res*. 1923;291:3-6.
3. Bedi A, Ryu RK. The treatment of primary anterior shoulder dislocations. *Instr Course Lect*. 2009;58:293-304.
4. Boileau P, Villalba M, Hery JY, Balg F, Ahrens P, Neyton L. Risk factors for recurrence of shoulder instability after arthroscopic Bankart repair. *J Bone Joint Surg Am*. 2006;88(8):1755-1763.
5. Borugian M, Spinelli J, Mezei G, Wilkins R, Abanto Z, McBride ML. Childhood leukemia and socioeconomic status in Canada. *Epidemiology*. 2005;16(4):526-531.
6. Bottoni C, Smith E, Berkowitz M, Towle R, Moore J. Arthroscopic versus open shoulder stabilization for recurrent anterior instability: a prospective randomized clinical trial. *Am J Sports Med*. 2006;34(11):1730-1737.
7. Chahal J, Leiter J, McKee MD, Whelan DB. Generalized ligamentous laxity as a predisposing factor for primary traumatic anterior shoulder dislocation. *J Shoulder Elbow Surg*. 2010;19(8):1238-1242.
8. Chahal J, Marks PH, Macdonald PB, et al. Anatomic Bankart repair compared with nonoperative treatment and/or arthroscopic lavage for first-time traumatic shoulder dislocation. *Arthroscopy*. 2012;28(4):565-575.
9. Cho NS, Hwang JC, Rhee YG. Arthroscopic stabilization in anterior shoulder instability: collision athletes versus noncollision athletes. *Arthroscopy*. 2006;22(9):947-953.
10. Cho NS, Yi JW, Lee BG, Rhee YG. Revision open Bankart surgery after arthroscopic repair for traumatic anterior shoulder instability. *Am J Sports Med*. 2009;37(11):2158-2164.
11. Fisher LD, Lin DY. Time-dependent covariates in the Cox proportional hazards regression model. *Annu Rev Public Health*. 1999;20:145-157.
12. Freedman KB, Smith AP, Romeo AA, Cole BJ, Bach BR Jr. Open Bankart repair versus arthroscopic repair with transglenoid sutures or bioabsorbable tacks for recurrent anterior instability of the shoulder: a meta-analysis. *Am J Sports Med*. 2004;32(6):1520-1527.
13. Green MR, Christensen KP. Arthroscopic versus open Bankart procedures: a comparison of early morbidity and complications. *Arthroscopy*. 1993;9(4):371-374.
14. Hattrup SJ, Cofield RH, Weaver AL. Anterior shoulder reconstruction: prognostic variables. *J Shoulder Elbow Surg*. 2001;10(6):508-513.
15. Hervey SL, Purves HR, Guller U, Toth AP, Vail TP, Pietrobon R. Provider volume of total knee arthroplasties and patient outcomes in the HCUP-Nationwide inpatient sample. *J Bone Joint Surg Am*. 2003;85:1775-1783.
16. Hobby J, Griffin D, Dunbar M, Boileau P. Is arthroscopic surgery for stabilization of chronic shoulder instability as effective as open surgery? A systematic review and meta-analysis of 62 studies including 3044 arthroscopic operations. *J Bone Joint Surg Br*. 2007;89(9):1188-1196.
17. Hovelius L, Olofsson A, Sandstrom B, et al. Nonoperative treatment of primary anterior shoulder dislocation in patients forty years of age and younger: a prospective twenty-five year follow-up. *J Bone Joint Surg Am*. 2008;90:945-952.
18. Imhoff AB, Ansah P, Tischer T, et al. Arthroscopic repair of anterior-inferior glenohumeral instability using a portal at the 5:30-o'clock position: analysis of the effects of age, fixation method and concomitant shoulder injury on surgical outcomes. *Am J Sports Med*. 2010;38(9):1795-1803.
19. Jain N, Pietrobon R, Hocker S, Guller U, Shankar A, Higgins LD. The relationship between surgeon and hospital volume and outcomes for shoulder arthroplasty. *J Bone Joint Surg Am*. 2004;86:496-505.
20. Johns Hopkins University Bloomberg School of Public Health, Health Services Research & Development Center. *The Johns Hopkins ACG® Case-Mix System Version 6.0 Release Notes*. Weiner JP, ed. Baltimore, MD: Johns Hopkins University; April 2003.
21. Katz JN, Losina E, Barrett J, et al. Association between hospital and surgeon procedure volume and outcomes of total hip replacement in the United States medicare population. *J Bone Joint Surg Am*. 2001;83(11):1622-1629.
22. Krueger D, Kraus N, Pauly S, Chen J, Scheibel M. Subjective and objective outcome after revision arthroscopic stabilization for recurrent anterior instability versus initial shoulder stabilization. *Am J Sports Med*. 2011;39(1):71-77.
23. Lenters TR, Franta AK, Wolf FM, Leopold SS, Matsen FA III. Arthroscopic compared with open repairs for recurrent anterior shoulder instability: a systematic review and meta-analysis of the literature. *J Bone Joint Surg Am*. 2007;89(2):244-254.
24. Lyman S, Koulouvaris P, Sherman S, Do H, Mandl LA, Marx RG. Epidemiology of anterior cruciate ligament reconstruction. *J Bone Joint Surg Am*. 2009;91:2321-2328.
25. Mazzocca AD, Brown FM Jr, Carreira DS, Hayden J, Romeo AA. Arthroscopic anterior shoulder stabilization of collision and contact athletes. *Am J Sports Med*. 2005;33(1):52-60.
26. Mohtadi NG, Bitar IJ, Sasyniuk TM, Hollinshead RM, Harper WP. Arthroscopic versus open repair for traumatic anterior shoulder instability: a meta-analysis. *Arthroscopy*. 2005;21(6):652-658.
27. Owens BD, Harrast JJ, Hurwitz SR, Thompson TL, Wolf JM. Surgical trends in Bankart repair: an analysis of data from the American Board of Orthopaedic Surgery certification examination. *Am J Sports Med*. 2011;39(9):1865-1869.
28. Park-Wyllie LY, Mamdani MM, Juurlink DN, et al. Bisphosphonate use and the risk of subtrochanteric or femoral shaft fractures in older women. *JAMA*. 2011;305(8):783-789.
29. Petrera M, Patella V, Patella S, Theodoropoulos J. A meta-analysis of open versus arthroscopic Bankart repair using suture anchors. *Knee Surg Sports Traumatol Arthrosc*. 2010;18(12):1742-1747.
30. Rhee YG, Ha JH, Cho NS. Anterior shoulder stabilization in collision athletes: arthroscopic versus open Bankart repair. *Am J Sports Med*. 2006;34(6):979-985.
31. Rowe CR, Zarins B, Ciullo JV. Recurrent anterior dislocation of the shoulder after surgical repair: apparent causes of failure and treatment. *J Bone Joint Surg Am*. 1984;66(2):159-168.
32. Speer KP, Deng X, Borrero S, Torzilli PA, Altcheck DA, Warren RF. Biomechanical evaluation of a simulated Bankart lesion. *J Bone Joint Surg Am*. 1994;76(12):1819-1826.
33. Twisk JW, Smidt N, de Vente W. Applied analysis of recurrent events: a practical overview. *J Epidemiol Community Health*. 2005;59(8):706-710.
34. Voos JE, Livermore RW, Feeley BT, et al. Prospective evaluation of arthroscopic Bankart repairs for anterior instability. *Am J Sports Med*. 2010;38(2):302-307.
35. Williams JI, Young W. A summary of studies on the quality of health care administrative databases in Canada. In: Goel V, Williams JI, Anderson GM, Blackstien-Hirsch P, Fooks C, Naylor CD, eds. *Patterns of Health Care in Ontario, The ICES Practice Atlas*. 2nd ed. Ottawa, ON: Canadian Medical Association; 1996:339-345.