Journal of Pediatric Orthopaedics
22:52–61 © 2002 Lippincott Williams & Wilkins, Inc., Philadelphia

Pediatric Shoulder Instability: Presentation, Findings, Treatment, and Outcomes

NOTICE: THIS MATERIAL MAY BE
Protected by Copyright Law
(Title 17 U.S. Code)

Richard L. Lawton, M.D., Sambhu Choudhury, M.D, Pierre Mansat, M.D., Robert H. Cofield, M.D., and Anthony A. Stans, M.D.

Study conducted at the Mayo Clinic, Rochester, Minnesota, U.S.A.

Summary: There is no one large study on pediatric shoulder instability. The purposes of this study were to characterize patients with shoulder subluxation or dislocation, the treatments provided, outcomes, and the predictors of good outcomes. Seventy shoulders in 66 patients were retrospectively reviewed, all with follow-up >2 years. The authors defined characteristics, treatment, outcomes, and associations between patient and treatment variables and outcome measures. Instability was associated with boys, adolescents, and trauma. Forty-two shoulders received physical therapy, and 28 required surgery. At follow-up, 54 of 70 described their shoulders as "better" or "much better," and 90% were performing at the same or higher levels of sports and work. Surgically treated patients were less likely to have recurrent instability or to report limitations. The current study is a large study of pediatric shoulder instability. Surgery improved stability, but overall, stability improved over time, with few patients having limitations at moderate- to long-term follow-up. **Key Words:** Dislocation—Instability—Pediatric—Shoulder—Subluxation.

Pediatric shoulder instability continues to be a significant clinical problem (3–7,11,12,15,17,19,23,27,40,49). The only previous series of recurrent shoulder dislocations in children was by Wagner and Lyne (44), who reported on nine children with dislocations presenting with open epiphysis, all of whom were treated with immobilization and physical therapy. Eight of 10 shoulders had recurrent instability, and all eight eventually underwent surgical intervention. The other literature refers to instability in pediatric subgroups insofar as they are part of the larger group of all patients with instability (16,22, 23,25,32,45). For example, Rowe (41,42) noted that 19.8% of his 500 patients were younger than age 20 at the time of their first dislocation, and Maruyama et al. (30) found peak incidence between ages 15 and 30. In these and other studies, young age has been associated with a problematic course. Age was the most important factor with respect to recurrence in Rowe's study of 500 patients (42), in which those dislocating before age 10 experienced a 100% recurrence rate. McLaughlin and McLellan (32) similarly found young age to predict recurrence, 96% of which occurred before the age of 30. Hovelius et al. (22,23,25) reported 2-, 5-, and 10-year follow-ups in patients with an additional shoulder dislocation, in which as many as 70% of patients from 12 to 16 years had recurrent dislocations with or without surgical treatment at final follow-up. Other authors have had similar results (20,28,33,36,45,48), although none have isolated the pediatric group as the primary focus.

There is a void in the data available to guide care for such patients, and it is unknown how they present and how they respond to treatment. For example, it is unclear whether children are similar to adult patients with the same diagnosis or whether they require different treatment, in the same way that certain pediatric fracture patients require different management than adult fractures at the same anatomic sites. The purposes of our study were to characterize pediatric patients presenting with shoulder instability regarding demographics, history, physical examination, and radiographic findings; to report treatments provided; to describe results; and to determine the variables predicting outcome of either surgical or nonsurgical treatment.

MATERIALS AND METHODS

Using a computerized database, all patients treated for shoulder instability, subluxation, or dislocation from 1976 to 1996 were retrospectively reviewed. Patients were included in the study if they were 16 years old or younger at the time of their first episode of instability or presentation. Patients were excluded if they had under-

Address correspondence and reprint requests to Dr. Richard L. Lawton, c/o Dr. Robert H. Cofield, Mayo Clinic, 200 First Street, S.W, Rochester, MN 55905, U.S.A.

From the Mayo Clinic, Rochester, Minnesota, U.S.A.

gone surgical treatment before presentation at our institution.

The records of 107 shoulders in 101 consecutive patients were reviewed for history, prior treatment, current symptoms, physical examination, radiographs, treatment, short-term follow-up (6–24 months), moderate- to long-term follow-up (2–21 years), complications, persistence or resolution of instability, and the need for subsequent treatment. Seventy patients had follow-up greater than 2 years, with a mean duration of 100 months (range 24–256). Mean age at the initial episode of instability was 13.2 years (range 4–16); the most recent follow-up was at 23.7 years of age (Fig. 1).

Statistical analyses were carried out with SPSS (Chicago, IL, U.S.A.) and included chi-square tests for discrete data, Pearson correlation for interval dependent variables, and analysis of variance for continuous data. Statistical significance was assigned at $P < 0.05$.

Factor analysis was used to help understand some of the complex relationships that exist between the many variables included in this study. This multivariate statistical tool was used to find patterned relationships or underlying order within the variables (44). Groups of related variables can be functionally clumped together as a single family of variables, which is valuable for several reasons. First, it helps detect underlying complex relationships without running multiple univariate tests and concomitantly incurring the possibility of spurious type 1 errors. Second, and more important in this case, it permits investigators to link characteristics of history, physical examination, and treatment with those of outcome, and thus determine which of many variables are associated with good and poor outcomes.

RESULTS

Historical Data

Demographic data was collected on 70 shoulders in 66 patients (44 boys, 22 girls). Both shoulders were involved in four patients (two boys and two girls). Thirty-eight right and 31 left shoulders were affected. The dominant side was affected in 38 cases.

Figure 1 illustrates the average ages of the patients at the time of the first episode of instability, diagnosis, first treatment, surgery, and follow-up. Average age at the first episode of instability was 13.4 years; it was significantly lower among girls than boys (12.0 vs. 14.1 years, $P = 0.003$) and was lower among patients with instability that was atraumatic (8.7 years), voluntary (8.7 years), or multidirectional (10.3 years; all $P < 0.0001$, Table 1). Mean age at diagnosis was 14.7, and age at first treatment was 15.5.

Trauma was associated with the onset of the first instability episode in 60 (86%). The most common activities and mechanisms, in descending order, were football, falls, basketball, wrestling, hockey, baseball or softball, swimming, and tennis (Fig. 2). When compared with those with no identifiable trauma at onset, patients with traumatic onset were older at the time of their first instability episode (14.2 vs. 9.3 years), at diagnosis (15.6 vs. 10.2 years), and at first treatment (16.0 vs. 13.2 years). There was no statistical age difference between

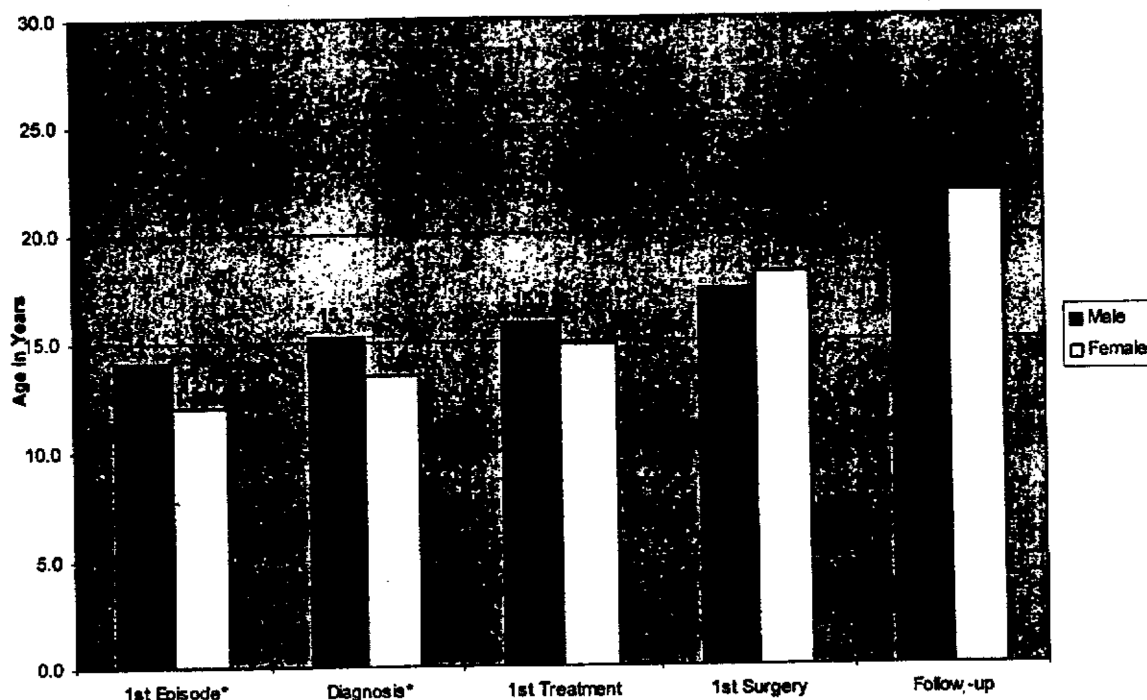

FIG. 1. Pediatric shoulder instability: age by events. $^{*}P < 0.05$.

TABLE 1. *Patient and shoulder instability characteristics*

	Row n	Traumatic onset		Direction of instability			Degree of instability		Voluntary instability
		Yes	No	Anterior	Posterior	Multi-directional	Subluxation	Dislocation	
Column n	70	60	10	53	2	15	35	35	11
Sex									
Boys	46	41	5	38	1	7	24	22	4
Girls	24	19	5	15	1	8	11	13	7*
Age at first episode									
Mean (years)	13.4	14.2†	8.7	14.3	14.0	10.3‡	13.3	13.5	8.7§
<10 years	7	2†	5	1	0	6‡	3	4	6§
10–13 years	16	12†	4	9	1	6‡	11	5	4§
>13 years	47	45†	1	43	1	3‡	21	26	1§
Final treatment method									
Surgery	28	26	2	23	0	5	16	12	2
Physical therapy	42	34	8	30	2	10	19	23	9

* Girls were significantly more likely than boys to have voluntary instability ($P < 0.05$).
† Patients with traumatic onset were significantly older than those with atraumatic onset ($P < 0.001$).
‡ Patients with multidirectional instability were significantly younger than those with anterior instability ($P < 0.001$).
§ Patients with voluntary instability were significantly younger than those without instability ($P < 0.001$).

patients receiving physical therapy only versus surgery as their primary treatment.

Regarding the degree of instability by history, of the 70 unstable shoulders, 35 (50%) were primarily subluxators without dislocation, and they reported an average of 11.6 episodes of subluxation (range 1–50) before presenting at our clinic. Patients were defined as subluxators if subluxation could be reliably determined by history or if it could be reproduced on physical examination. The remaining 35 (50%) unstable shoulders experienced dislocation as their primary complaint, averaging 5.8 dislocations each. Patients were defined as dislocators if dislocation had been documented by a physician's physical examination or radiographs. Only three patients had a family history of shoulder instability.

Other symptoms included, at the time of presentation at our clinic, restriction of activities (51% of 70 shoulders) followed by pain (28%), apprehension (26%), voluntary subluxation (21%), loss of motion (11%), weakness (5%), and impingement symptoms (4%).

Before arrival at our clinic, 33 patients (47%) were immobilized and none had undergone surgery.

Physical examination

At the pretreatment physical examination at our institution, motion and strength were generally well preserved. Mean elevation of the affected shoulder was 175°, external rotation to 72°, and internal rotation to T7. The anterior apprehension test was positive in 51 (73%) of the shoulders. In three patients a positive result on the impingement test was elicited. Passive translocation of the head of the humerus in neutral rotation was moderate or severe (to the point of dislocation) in the anterior direction in 24 patients, in the posterior direction in 4 patients, in the anterior-inferior direction in 21 patients. Strength was normal in planes of abduction, flexion, and internal and external rotation. Eleven (16%) of the patients had voluntary instability on physical examination. These patients were younger ($P < 0.001$) and more likely to be girls ($P < 0.05$). Voluntary instability was present

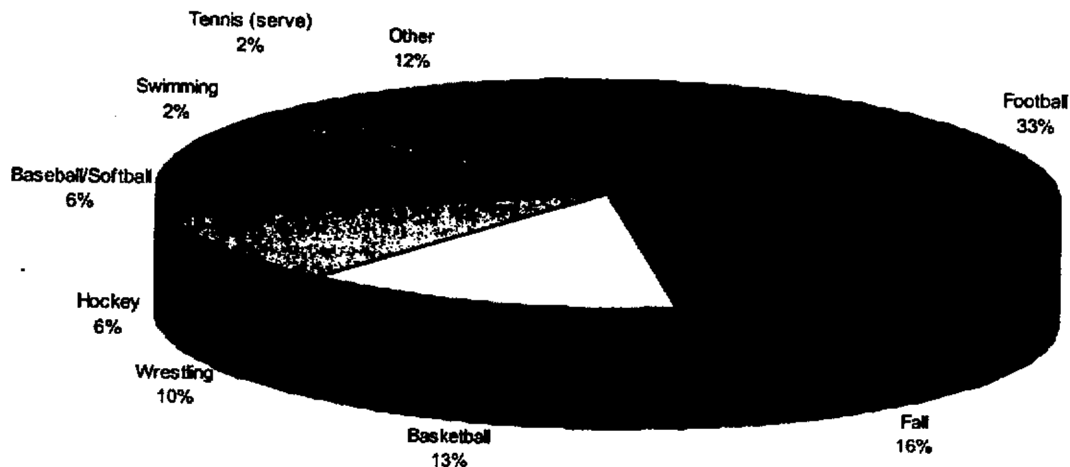

FIG. 2. Pediatric shoulder instability: traumatic onset by mechanism (n = 60).

in seven (29%) of the girls' shoulders compared with four (9%) of the boys' shoulders ($P < 0.05$).

Radiographs were available for 26 patients, of whom 16 (61%) had Hill-Sachs lesions and 11 (42%) had bony Bankart lesions. Those eventually undergoing surgery at our center were more likely to have a Hill-Sachs lesion than those managed without surgery.

Treatment

After evaluation at our clinic, only two patients were treated with continued immobilization; 47 (67%) began physical therapy and 28 (40%) eventually underwent surgery. Of the 28 operated shoulders, 18 (65.8%) had participated in physical therapy before surgery. Bankart repairs with capsular shift were performed in 11 (39%) of the surgical patients, Bristow procedures in 5 (18%), Putti-Platt procedures in 3 (11%), capsular shift in 3 (11%), and Bankart repair alone (no capsular shift) in 1 (4%). One patient had an arthroscopic anterior Bankart repair with capsular tightening.

There were no differences in the frequencies with which surgery was used to treat patients with traumatic versus atraumatic onset, across different directions of instability (anterior vs. posterior vs. multidirectional instability), or degree of instability (dislocating patients vs. those with subluxation alone). Surgery was used less often among patients with voluntary instability compared with those without, a trend that approached statistical significance.

There were no surgical complications. Six patients originally treated with physical therapy at our institution went on to have surgery performed elsewhere for recurrent or worsening symptoms. Of these six, two experienced improvement after the surgery performed elsewhere. Patients treated with surgery were less likely to report symptoms of instability at follow-up (Table 2).

Among patients with >2 years of follow-up, six (9%) patients had recurrent instability; of these, two had dislocated and the remaining four had subluxation. Both of the patients with dislocation had been treated with physical therapy alone at our institution. One (4%) of the 28 surgically treated patients with >2 years of follow-up had recurrent dislocations.

Moderate- to long-term follow-up

Follow-up data beyond 2 years was available for 70 shoulders at a mean of 8.5 years (range 2–21) after initial treatment at our institution. Of these, 28 (40%) underwent surgery; the remainder received physical therapy alone. Outcome measures included here are pain, stability, recurrent instability, and self-assessed ratings of improvement, sports and work participation, as well as limitations.

Forty-five (64%) shoulders were rated by patients as

TABLE 2. *Pain and instability at moderate- to long-term follow-up*

		Traumatic onset		Direction of instability			
	Row n	Yes	No	Anterior	Posterior	Multi-directional	Voluntary instability
Pain							
Column n	70	60	10	53	2	15	11
Little or none	45	37	8	37	0	8	6
Surgical	17	15	2	13	0	4	2
PT	28	22	6	24	0	4	4
Mild discomfort	17	16	1	10	2	5	4
Surgical	5	5	0	5	0	0	0
PT	12	11	1	5	2	5	4
Moderate discomfort	7	6	1	5	0	2	1
Surgical	6*	6	0	5	0	1	0
PT	1	0	1	0	0	1	1
Severe pain	1	0	1	0	0	0	0
Surgical	0	0	0	0	0	0	0
PT	1	0	1	0	0	1	0
Instability							
Column n	70	60	10	53	2	15	11
None	41	35	6	33	1	7	6
Surgical	21	20	1	18	0	3	1
PT	20	15	5	15	1	4	5
Apprehension only	22	19	3	15	1	6	3
Surgical	6	5	1	4	0	2	1
PT	16	14	2	11	1	4	2
Subluxation	4	3	1	3	0	1	1
Surgical	1	1	0	1	0	0	0
PT	3	2	1	2	0	1	1
Dislocation	2	2	0	1	0	1	1
Surgical	0	0	0	0	0	0	0
PT	2	2	0	1	0	1	1

PT, physical therapy.

* Surgically treated patients were more likely to report having moderate pain than those treated with physical therapy only ($P = 0.03$).

having little or no pain at all, and an additional 17 (24%) were described as having mild discomfort with work or sports. Seven (10%) were described as having moderate discomfort with overhead use and heavy lifting, and only one patient (1%) reported severe pain with most activities. When stratified by treatment modality (surgical vs. physical therapy alone), surgically treated patients were more likely to report moderate discomfort, which occurred in six (21%) of the surgically treated shoulders compared with one (2%) of those treated with physical therapy alone. Otherwise, there were no significant differences in pain when patients were stratified by traumatic versus atraumatic onset, voluntary instability, and direction of instability. Age at first episode was not related to stability.

Forty-one (59%) of the 70 patients had no instability findings or symptoms, whereas 22 (31%) had apprehension, 4 (6%) experienced subluxation, and 2 (3%) had recurrent dislocation. There were no significant differences in stability detected when patients were stratified by voluntary versus involuntary instability or direction of instability (anterior vs. posterior vs. multidirectional). By combining into one larger group of symptomatic patients those shoulders with apprehension, subluxation, and dislocation, the patients treated surgically were less likely to be symptomatic than those treated with physical therapy alone. In other words, rather than using an interval scale for measuring instability, by simplifying the measurement tool into simply the presence or absence of *any* sign or symptom of instability, the patients treated surgically were less likely to be symptomatic. Specifically, only seven (25%) of the patients treated surgically had signs or symptoms of instability, significantly fewer than the 21 (51%) of those treated with physical therapy alone ($P = 0.01$).

When asked to rate their shoulders overall since treatment, 32 of 70 patients described them as "much better," 22 as "better," 12 as "the same," and three as "worse." Seventy patients answered questions pertaining to sports performance, of whom 64 stated they were performing at the same or higher level than before their injury. Seventy patients answered questions pertaining to work performance, of whom 65 stated they were performing at the same or higher level than before their injury. Sixty-eight patients rated the overall function of their shoulder, of whom 34 described their shoulders as without limitations, 21 with "mild limitations of sports/work," 12 with "moderate limitation doing overhead work or heavy lifting," and one with "marked limitations (all overhead activity impossible)" (Table 3).

Among the 10 respondents with voluntary instability, only 2 described their shoulders as without limitations, a rate significantly lower than those without voluntary instability ($P < 0.05$). Patients undergoing surgical intervention reported less instability ($P < 0.01$).

Overall, traumatic onset, the number of dislocations, degree of instability (dislocation vs. subluxation), direction of instability, or participation in physical therapy did not affect self-ratings of function or limitations. Specifically, patients with traumatic onset did not have different function or limitations than those with atraumatic onset, and the same held true for those with dislocation compared with subluxation, those with different directions of instability, and those undergoing physical therapy compared with those who did not. However, when certain subgroups were analyzed, more complex relationships were detected. For example, surgical patients had better survey ratings than patients undergoing physical therapy if they had anterior instability or traumatic onset ($P < 0.05$).

There is a great deal of information in this study, with many analyses and significant findings; therefore, in an effort to condense some of the results into a more understandable form, we tried to determine which variables were associated with good and poor outcomes (Table 4). Outcomes were measured by stability, pain, symptomatic improvement, sports participation, work participation, and limitations. At moderate- to long-term follow-up, several patient characteristics were significantly related to good and poor outcomes. Stability was related to both sex (with boys significantly more stable) and surgery (with those undergoing surgery more stable than those receiving physical therapy alone). The other outcome variable significantly related to surgical treatment was self-rating of improvement, with those undergoing surgery reporting more improvement than those treated with physical therapy alone ($P = 0.001$). Pain was significantly related to surgical treatment, with those undergoing surgery more likely to report moderate pain than those receiving physical therapy alone ($P = 0.05$). In addition, patients with anterior instability had higher self-ratings of improvement than those with posterior or multidirectional instability ($P = 0.02$). Those with traumatic onset were more likely than those with atraumatic onset to be performing at the same or higher level of sports participation than before treatment ($P = 0.04$). The level of work participation was not associated with any of the patient or treatment variables. Self-ratings of limitations were significantly associated with sex (boys reporting fewer limitations, $P = 0.003$), direction of instability (multidirectional reporting more, $P = 0.0005$), and voluntary instability (reporting more, $P = 0.04$). In summary, these data show that surgical treatment was associated with more stability in short- and moderate- to long-term follow-up as well as self-ratings of improvement, despite an association with more pain. Other patient characteristics were associated with better self-ratings of function, including sex (boys had higher ratings than girls), anterior instability, traumatic onset, and absence of voluntary instability.

Factor analysis was applied to evaluate whether combinations of characteristics were predictive of good and poor outcomes. Four groups of variable relationships or patient profiles were detected. The first reflects a positive relationship between older boys with traumatic onset of their instability, absence of voluntary instability, treatment with surgery, and good outcomes both at clinical and survey follow-up. In other words, older boys with traumatic onset and no voluntary instability and who were treated surgically did better than patients who had

TABLE 3. *Shoulder improvement and function at moderate- to long-term follow-up*

	Row n	Traumatic onset		Direction of instability			Voluntary instability
		Yes	No	Anterior	Posterior	Multi-directional	
Column n	70	60	10	53	2	15	11
Much Better	32	28	4	26	0	6	4
Change Since Treatment							
Much better	32	28	4	26	0	6	4
Surgical	21	20*	1	17†	0	4	1
PT	11	8	3	1	0	2	3
Better	22	19	3	16	1	5	3
Surgical	6	5*	1	5†	1	1	1
PT	16	14	2	11	0	4	2
Same	12	9	3	7	1	4	4
Surgical	1	1*	0	1†	0	0	0
PT	11	8	3	6	1	4	4
Worse	3	3	0	3	0	0	0
Surgical	0	0	0	0	0	0	0
PT	3	3	0	3	0	0	0
Limitations							
Column n	68	59	9	52	14	2	10
None	34	31	3	28	5	1	2‡
Surgical	17	16	1	14	3	0	1
PT	17	15	2	14	2	1	1
Mild limitation in work/sports	21	17	4	12	8	1	7‡
Surgical	7	7	0	6	1	0	0
PT	11	10	4	6	7	1	7
Moderate limitation	12	10	2	11	1	0	1‡
Surgical	3	3	0	3	0	0	0
PT	9	7	2	8	1	0	1
All overhead activities impossible	1	1	0	1	0	0	0
Surgical	1	1	0	1	0	0	0
PT	0	0	0	0	0	0	0

PT, physical therapy.

* Patients with traumatic onset who were treated surgically were more likely than those treated with physical therapy only to give higher self-ratings of improvement ($P < 0.05$).

† Patients with anterior instability who were treated surgically were more likely than those treated with physical therapy only to give higher self-ratings of improvement ($P < 0.05$).

‡ Patients with voluntary instability were more likely than those without to report limitations in work or sports ($P < 0.05$).

fewer of those characteristics. The second grouping shows that older girls with traumatic dislocation and voluntary instability had poorer outcomes independent of treatment. The third grouping represents a positive relationship between multiple dislocations, atraumatic onset, treatment with physical therapy and surgery, and favorable outcome. In other words, patients who had those features treated with physical therapy before surgery were more likely to be stable and less likely to report limitations than those with fewer characteristics. The fourth group reflects a relationship between early atraumatic instability, multiple dislocations, voluntary instability, and poor outcome after surgical treatment: patients with these features did not do as well with surgery in terms of stability and function at follow-up.

DISCUSSION

The first purpose of the study was to characterize children with shoulder instability, a group that to date has

TABLE 4. *Relationships between patient/treatment characteristics and outcome measures*

Patient characteristics	Short-term follow-up	Moderate- to long-term follow-up					
	Instability	Instability	Pain	Self-rating of improvement	Level of sports participation	Level of work participation	Limitations
Sex	0.21	0.002	0.21	0.08	0.62	0.79	0.003
Direction of instability	0.20	0.89	0.13	0.02	0.46	0.95	0.0005
Trauma	0.47	0.87	0.09	0.78	0.04	0.40	0.69
Voluntary instability	0.78	0.15	0.31	0.42	0.12	0.43	0.04
Treatment (surgery vs. physical therapy only)	0.004	0.01	0.05	0.001	0.82	0.13	0.23

All values are P values.

been considered mostly a subgroup of studies of shoulder instability in patients of all ages.

Demographics, history, physical examination, and radiographic findings

Some general features of the current sample are worth noting and comparing to past work, age being among them. We used as inclusion criterion age of 16 or younger at the first episode of instability. Analyses and comments about age should be interpreted with this artificial and somewhat arbitrary limit in mind, with consideration given to the idea that instability occurs through middle age. However, that said, most patients in the study group were adolescents at the time of their first episode, with a mean age of 13.4 years, and the majority of patients (67%) were 14 or older. Patients were even a bit older if they experienced traumatic, anterior, or involuntary dislocations, which seem to resemble more closely an adult pattern of shoulder instability (1). There does seem to be a younger subgroup with different symptoms, more likely to have instability that is atraumatic in origin, multidirectional, and voluntary. However, in the current study, only seven (10%) of all patients were younger than 10 years old at the time of their first episode of instability, representing a small constituent of the overall group. The ability to detect differences between these very young patients and the adolescents is likely hindered in this case by the small number of patients in the former group.

Girls were younger than boys at their first episode of instability, giving credence to the idea that a relative increase in body size during the pubertal growth spurt leads to exposure of the shoulder to loads leading to failure. (The effects of age on recurrence and other outcome measures will be described below in the section on outcome.) Boys outnumbered girls almost two to one, analogous to patterns of supracondylar humerus and other fractures among boys and girls (10,47). Most patients (86%) had traumatic onset at their first episode of instability, paralleling adult studies in which most patients were male and had traumatic onset (43).

The most common complaints were of instability, restricted activities, and pain. Strength and range of motion were normal. The most common significant finding on physical examination was apprehension, which was present in 73% of patients. These findings are similar to those found in studies of older patients (29).

Patients were equally likely to have subluxation as complete dislocation (35 shoulders in each group). Among our sample, four patients (6%) had instability bilaterally, within the 2% to 24% range observed in other studies of patients of all ages (22,26,34,42).

Multidirectional instability and voluntary instability were present in 21% and 16% of the patients, respectively. Both entities were significantly more common among younger patients, and voluntary instability was more common among girls. Rowe et al. (38) reviewed 26 voluntary dislocators who were all first seen between the ages of 12 and 16. Nineteen of these patients first began to voluntarily dislocate their shoulder between the ages of 6 and 16. The initial dislocation occurred with minor trauma in 4, with simple twisting in 11, and voluntarily in 11. In a subsequent series, Maruyama et al. (30) similarly noted that young patients were more likely to sustain dislocations with minimal or no trauma.

Radiographic findings were similar to those found in adult or mixed populations. In the current sample, 26 patients had available radiographs, of whom 16 (62%) had Hill-Sachs lesions (21). Hovelius et al. (22) identified Hill-Sachs lesions in 53% of his mixed-age sample. Rowe (42) observed 82% recurrence in 47 shoulders with the Hill-Sachs lesion.

In summary, the characteristics of these patients closely parallel those in studies of patients of all ages.

Treatment

The second purpose of this study was to analyze treatment. A variety of treatments were provided to patients. Many received treatment outside our institution, and nearly half had been immobilized for various durations. Once at our institution, treatments similarly varied and were administered by a large number of physicians and therapists. Even among the surgical group there was variability, with patients undergoing one of seven different types of surgery performed by as many surgeons. Therefore, it seems difficult to draw many firm conclusions about the efficacy of any one treatment over another, and the reader is cautioned against this weakness of the study.

Similarly, it is hard to know in this retrospective study whether surgically treated patients were different than those treated more conservatively. Table 1 shows that there were no differences in the two treatment groups with respect to trauma, direction of instability, degree of instability, or the presence of voluntary instability. The groups were similar at least with respect to these variables.

Immobilization was used in only 2 of the 70 patients in the current sample, largely because many patients (51/70 [73%]) were immobilized before arrival at our institution and because of the historically poor results of this treatment modality. For example, Wagner and Lyne (44) found significant recurrence despite immobilization for 6 weeks in their pediatric population. Hovelius found similar results after 3 to 4 weeks of immobilization in 245 patients. Simonet and Cofield (43) described 116 patients, 32 of whom were younger than 20 years old, in whom there was no correlation between recurrence and immobilization, although higher success rates were found in patients with restriction of athletic activities for 6 weeks.

Physical therapy was widely used as the primary treatment of most shoulders in the current study, implemented in 47 (67%) as the initial form of treatment. It was the final form of treatment in 42 (60%). There was an insignificant trend toward using it more among those with voluntary instability.

Surgical patients represented 40% of the sample, a figure similar to that seen in prior studies of mixed-age patients diagnosed with shoulder instability. Simonet and

Cofield (43) found that 14 of 32 patients (44%) younger than 20 years required surgery, and Hovelius et al. (22) followed up 102 patients aged 12 to 22 for 10 years and found that only 33% needed surgery.

Outcomes

The third purpose of the study was to detect relationships between patient or treatment variables and outcome measures. The outcome measures included stability in the short term (6–24 months after initiation of treatment or surgery) and several variables measured at moderate- to long-term follow-up (2–21 years), including stability, pain, self-assessed ratings of improvement, and function, such as work, sports, and limitations.

At short-term follow-up, the only patient or treatment variable predictive of good outcome was surgical intervention, those undergoing surgery being more stable. One (4%) of the surgically treated patients had recurrent dislocation within that time frame, significantly lower than among those treated with physical therapy alone. Other patient characteristics, such as age, direction of instability, degree of instability, the presence of voluntary instability, traumatic onset, and sex, were not associated with any difference in stability at short-term follow-up. Possible reasons for this might include low power: because only 38 patients had follow-up data available during this time window, analyses were handicapped by low cell numbers and high error variances.

At moderate- to long-term follow-up, there were more significant relationships between patient and treatment variables and outcome measures (Table 4). Surgical treatment was associated with more stability and higher self-ratings of improvement. Existing literature on mixed-age populations show similar results. Wheeler et al. (46) found that seven of nine (77.8%) surgically treated patients avoided recurrence at follow-up. Arciero et al. (2) observed no recurrence in 31 of 36 surgically treated patients with a mean age of 19 years. Further insight was provided by analysis of subgroups, which showed that, at clinical follow-up, the following patients did better with surgical treatment: those with traumatic onset, anterior instability, multidirectional instability, and subluxation. Surgery did not affect outcome in those with posterior instability, voluntary instability, and atraumatic onset.

Results of physical therapy varied across different outcome measures. At short-term follow-up, 9 of 15 of patients had not experienced any episodes of instability, but at survey follow-up 27 of 41 patients treated with physical therapy described their shoulders as "better" or "much better." The existing literature describes variable results with physical therapy, with 15% to 83% of patients achieving good results (8,38) and atraumatically unstable patients achieving the best results.

Recurrent instability (either dislocation or subluxation) was not an infrequent event among the patients in this study, occurring in 24% of patients at short-term follow-p, and in 9% at moderate- to long-term follow-up. Dislocation alone (without subluxation) occurred in five (13%) patients at short-term follow-up and two (3%) at moderate- to long-term follow-up. Recurrent dislocation at short-term and moderate- to long-term follow-up was less likely to occur among surgically treated patients. To date, most of the literature states that young patients with instability are more likely to have recurrence than adults, especially older adults, and no consensus exists about the treatment of children with instability (16,20,22,23,25,28, 30,32,36,41,42,44,45,48). Recurrent instability has been observed at rates as high as 70% to 100% in some series (31,41,44). The results of the current study are clearly lower than these earlier observations, possibly because the former represent an older population closer to adult patients with respect to their anatomy and pathology. As mentioned earlier, several dislocating patients were excluded from the study because they lacked adequate follow-up. Had they been included, the incidence of recurrence, especially among surgical patients, would have been higher. In adults, recurrent signs or symptoms of instability indicate the need for surgical intervention (1). Recurrence is less likely the older the patient is at the time of the initial dislocation (23,44). Arthroscopic and open procedures have been variably successful in adults, reducing recurrence from 4.5% to 22% among arthroscopically treated patients (13,18,35,47) to 5% to 8% of those treated open (24,37,39). The data from this study seem to more closely parallel the findings among this population than among those observed in the very young.

The idea that the very young represent a different disease than in older patients is one treated ambivalently by the data in the current study. Although voluntary, multidirectional, and atraumatic instability are all associated with young age (mean age for each was younger than 9 years), outcomes were not associated with age effects. Stability at short-term or moderate- to long-term follow-up was not related to age; neither were pain or patient ratings of improvement, sports, work, or limitations. We cannot explain why recurrence was not observed at high levels in these young patients, as had been seen in past studies.

Further insight into the complex relationships between outcome and other variables was provided by factor analysis. There was a positive relationship between better outcome and a combination of older age, male sex, traumatic onset, surgical intervention, and the absence of voluntary instability: that is, patients with these characteristics (older boys with traumatic origin, surgically treated) were more likely to be stable and rate their shoulder more favorably than those with different patient characteristics. In contradistinction, there were two variable groupings associated with poor outcomes. The first was a combination of female sex, older age, traumatic onset, and dislocation; the second was a combination of young age at onset, atraumatic onset, and multiple, voluntary dislocations treated with surgery.

These findings, taken together, indicate that there are several variables that might have prognostic value and help guide treatment decisions. Older boys with traumatic onset had better outcomes, and girls or those with multidirectional and voluntary instability did worse. Per-

haps the most significant variable is voluntary instability, the presence of which was associated with poorer functional outcomes and a poor response to surgery. This is consistent with some prior work in which joint laxity has been associated with recurrence (9,14,16). However, taking the next inferential step and making treatment choices is difficult. As noted earlier, this is a retrospective study in which several surgeons performed several different procedures during a 20-year span. Further, there were too few cases of each surgery to compare one procedure against the others. Despite this, several different analyses (univariate, multivariate/discriminant analyses) show some benefit of surgery. As stated above, surgical patients were more stable at both short-term and moderate- to long-term follow-up and had higher self-ratings of improvement. Whether these patients would have done better without surgery is unknowable. Older patients at or near skeletal maturity with traumatic anterior dislocations seem to be the most suitable surgical candidates for a variety of reasons, including the data presented here. Also, their pathology more closely resembles that in adult patients, about whom the pathology and responses to a variety of surgical techniques are well documented. Indeed, among the patients in the current study undergoing surgery, mean age at the time of first surgery was 18.2 years for boys, an adult age by most standards.

There are several limitations of this study. It was retrospective, and treatment was not randomly assigned or randomized. It took place at a tertiary care center where the patient population was affected by sampling bias, and many patients received some form of treatment before their evaluation and treatment at our institution. In addition, as noted earlier, several surgeons performed a variety of procedures. Arthroscopic surgery was performed on only one patient. Laser and thermal capsulorrhaphy procedures were not performed. Short-term follow-up data were collected on a subgroup of patients and may not represent the larger group accurately. A prospective study in which patients are randomly assigned to either a standardized therapy program or a specific surgical procedure would help address some of these weaknesses.

REFERENCES

1. Arciero R, Wheeler J, Ryan J, McBride J. Arthroscopic Bankart repair versus nonoperative treatment of acute initial anterior shoulder dislocations. *Am J Sports Med* 1994;22:589.
2. Asher M. Dislocations of the upper extremity in children. *Orthop Clin North Am* 1976;7:583.
3. Aulicino P, Reintert C, Komberg M, Williamson S. Displaced intra-articular glenoid fractures treated by open reduction and internal fixation. *J Trauma* 1986;26:1137.
4. Barry T, Lombardo S, Kerlan R, et al. The coracoid transfer for recurrent anterior instability of the shoulder in adolescents. *J Bone Joint Surg [Am]* 1985;67:383.
5. Biro F, Gewanter H, Baum J. The hypermobility syndrome. *Pediatrics* 1983;72:701.
6. Brewer BJ, Wubben RC, Carrera GF. Excessive retroversion of the glenoid cavity. A cause of nontraumatic posterior instability of the shoulder. *J Bone Joint Surg [Am]* 1986;68:724.
7. Burkhead W, Rockwood C. Treatment of instability of the shoulder with an exercise program. *J Bone Joint Surg [Am]* 1992;74:890.
8. Carter C. Recurrent dislocation of the patella and of the shoulder. *J Bone Joint Surg [Br]* 1960;42:721.
9. Cheng JS, Shen WY. Limb fracture pattern in different pediatric age groups: a study of 3350 children. *J Trauma* 1993;7:15.
10. Cofield R, Nessler J, Weinstabl R. Diagnosis of shoulder instability by examination under anesthesia. *Clin Orthop* 1993;291:45.
11. Cofield R. Arthroscopy of the shoulder. *Mayo Clin Proc* 1983;58:501.
12. DeBerardino TM, Arciero RA, Taylor DC. Arthroscopic stabilization of acute initial anterior shoulder dislocation: the West Point experience. *J South Orthop Assoc* 1996;5:263–71.
13. Dubs L, Gschwend N. General and joint laxity: quantification and clinical relevance. *Arch Orthop Trauma Surg* 1988;107:65.
14. Emery R, Mullaji A. Glenohumeral joint instability in normal adolescents: incidence and significance. *J Bone Joint Surg [Br]* 1991;73:406.
15. Finsterbush A, Pogrund H. The hypermobility syndrome: musculoskeletal complaints in 100 consecutive cases of generalized joint hypermobility. *Clin Orthop* 1982;168:124.
16. Freundlich B, Denno J. Transverse fracture of the glenoid without dislocation. *Orthop Rev* 1987;16:89.
17. Green MR, Christensen KP. Arthroscopic Bankart procedure: two- to five-year follow-up with clinical correlation to severity of glenoid labral lesion. *Am J Sports Med* 1995;23:276–81.
18. Gusmer P, Potter H. Imaging of the shoulder instability. *Clin Sports Med* 1995;14:777.
19. Henry J, Genung J. Natural history of glenohumeral dislocation, revisited. *Am J Sports Med* 1982;10:135.
20. Hill H, Sachs M. The grooved defect of the humeral head. A frequently unrecognized complication of dislocation of the shoulder joint. *Radiology* 1940;35:690.
21. Hovelius L, Augustini G, Fredin O, et al. Primary anterior dislocation of the shoulder in young patients. *J Bone Joint Surg [Am]* 1996;78:1677–86.
22. Hovelius L, Lind B, Thorling J. Primary dislocation of the shoulder. Factors affecting the two-year prognosis. *Clin Orthop* 1983;176:181.
23. Hovelius L, Thorling J, Fredin H. Recurrent anterior dislocation of the shoulder: results after the Bankart and Putti-Platt operations. *J Bone Joint Surg [Am]* 1979;61:566–9.
24. Hovelius L. Anterior dislocation of the shoulder in teen-agers and young adults. Five-year prognosis. *J Bone Joint Surg [Am]* 1987;69:393.
25. Ireland ML, Hutchinson MR. Upper extremity injuries in young athletes. *Clin Sports Med* 1995;14:533.
26. Jesse E, Owen D, Sagar K. The benign hypermobile syndrome. *Arthritis Rheum* 1980;23:1053.
27. Kuviluoto O, Pasila M, Jaroma H, Sundholm A. Immobilization after primary dislocation of the shoulder. *Acta Orthop Scand* 1980;51:915.
28. Liu SH, Henry SH. Anterior shoulder instability. *Clin Orthop* 1996;323:327–37.
29. Maruyama K, Sano S, Saito K, Hamaguchi Y. Trauma instability voluntarism classification for glenohumeral instability. *J Shoulder Elbow Surg* 1995;4:194.
30. McGlynn FJ, Caspari RB. Arthroscopic findings in the subluxating shoulder. *Clin Orthop* 1984;183:173.
31. McLaughlin H, McLellan D. Recurrent anterior dislocation of the shoulder II. A comparative study. *J Trauma* 1967;7:191.
32. Morrey B, Janes J. Recurrent anterior dislocation of the shoulder: long-term follow-up of the Putti-Platt and Bankart Procedures. *J Bone Joint Surg [Am]* 1976;58:252.
33. O'Driscoll SW, Evans DC. Contralateral shoulder instability following anterior repair. *J Bone Joint Surg [Br]* 1991;73:941–6.
34. Pagnani MJ, Warren RF, Altchek DW, et al. Arthroscopic shoulder stabilization using transglenoid sutures: a 4-year minimum follow-up. *Am J Sports Med* 1996;24:459–67.
35. Pollock RG, Flatow EL. In: The unstable shoulder. Bigliani (ed). Chicago, IL, 1995:25–36.
36. Relovszky K, Relovszky E. Prognosis of primary dislocation of the shoulder. *Acta Orthop Scand* 1969;40:216.
37. Rowe CR, Patel D, Southmayd WW. The Bankart procedure: a study of late results. *J Bone Joint Surg [Br]* 1977;59:122.

38. Rowe C, Pierce D, Clark J. Voluntary dislocation of the shoulder. *J Bone Joint Surg [Am]* 1973;55:445.
39. Rowe CR, Zarins B. Recurrent transient subluxation of the shoulder. *J Bone Joint Surg [Am]* 1981;63:863–72.
40. Rowe C. Acute and recurrent anterior dislocations of the shoulder. *Orthop Clin North Am* 1980;11:253.
41. Rowe C. Anterior dislocations of the shoulder: prognosis and treatment. *Surg Clin North Am* 1963;43:1609.
42. Rowe C. Prognosis in dislocations of the shoulder. *J Bone Joint Surg [Am]* 1956;38:957.
43. Simonet W, Cofield R. Prognosis in anterior shoulder dislocation. *Am J Sports Med* 1984;12:19.
44. Wagner K, Lyne E. Adolescent traumatic dislocations of the shoulder with open epiphysis. *J Pediatr Orthop* 1983;3:61.
45. Watson-Jones R. Recurrent dislocation of the shoulder [editorial]. *J Bone Joint Surg [Br]* 1948;30:49–52.
46. Wheeler J, Ryan J, Arciero R, Molinari R. Arthroscopic versus nonoperative treatment of acute shoulder dislocations in young athletes. *Arthroscopy* 1989;5:213.
47. Wilkins KE. Fractures and dislocations of the elbow region. In Rockwood CA, Wilkins KE, Beatty JH, eds. *Fractures in children*, 4th ed. Philadelphia: Lippincott-Raven; 1996.
48. Wirth MA, Blatter G, Rockwood CA Jr. The capsular imbrication procedure for recurrent anterior instability of the shoulder. *J Bone Joint Surg [Am]* 1996;78:256–9.