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Characteristics of functional shoulder instability

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Background: Pathologic activation pattern of muscles can cause shoulder instability. We propose to call this pathology functional shoulder instability (FSI). The purpose of this prospective study was to provide an in-detail description of the characteristics of FSI.

Methods: In the year 2017, a total of 36 consecutive cases of FSI presenting to our outpatient clinic were prospectively collected. Diagnostic investigation included a pathology-specific questionnaire, standardized clinical scores, clinical examination, psychological evaluation, video and dynamic fluoroscopy documentation of the instability mechanism, as well as magnetic resonance imaging (MRI). In a final reviewing process, the material from all collected cases was evaluated and, according to the observed pattern, different subtypes of FSI were determined and compared.

Results: Based on the pathomechanism, positional FSI (78%) was distinguished from nonpositional FSI (22%). Controllable positional FSI was observed in 6% of all cases and noncontrollable positional FSI in 72%, whereas controllable and noncontrollable nonpositional FSI were each detected in 11% of the cases. The different subtypes of FSI showed significant differences in all clinical scores (Western Ontario Shoulder Instability Index: $P = .002$, Rowe Score: $P = .001$, Subjective Shoulder Value: $P = .001$) and regarding functional impairment (shoulder stability: $P < .001$, daily activities: $P = .001$, sports activities: $P < .001$). Seventy-eight percent had posterior, 17% anterior, and 6% multidirectional instability. Although several patients showed constitutional glenoid shape alterations or soft tissue hyperlaxity, only few patients with acquired minor structural defects were observed.

Conclusion: FSI can be classified into 4 subtypes based on pathomechanism and volitional control. Depending on the subtype, patients show different degrees of functional impairment. The majority of patients suffer from unidirectional posterior FSI.

Level of evidence: Level IV; Case Series; Prognosis Study

Keywords: Shoulder instability; functional shoulder instability; voluntary shoulder instability; positional shoulder instability; noncontrollable shoulder instability; multidirectional shoulder instability; posterior shoulder instability; anterior shoulder instability

This study was performed at the Department for Shoulder and Elbow Surgery, Center for Musculoskeletal Surgery, Campus Virchow, Charité-Universitaetsmedizin Berlin, Berlin, Germany.
This study was approved by the ethical committee of the Charitè University, Berlin, Germany (EA2/195/16).

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Shoulder instability is a common and well-studied pathology. Even though there are still debates and differences of opinion regarding certain topics, the diagnosis, classification, and treatment of shoulder instability in general has reached a high level of standardization among shoulder surgeons. Several biomechanical as well as clinical studies have revealed that structural defects are the main cause for shoulder instability.[2,5,6,31,35,43,44] However, in addition to structural defects, pathological muscle activation patterns have been found to cause shoulder instability even in the absence of structural defects.[22] We propose to call this form of instability functional shoulder instability (FSI) as opposed to instability caused by structural defects. Current classification systems for shoulder instability include patients with FSI in different ways. Although the TUBS (Traumatic, Unidirectional, Bankart Lesion, Surgery) and AMBRI (Atraumatic, Multidirectional, Bilateral, Rehabilitation, Inferior Capsular Shift) classification systems do not specifically mention FSI,[42] the Stanmore classification describes patients with an abnormal muscle activation pattern under the group Polar Type 3.[29] Among patients with FSI, the distinction between the unwanted dislocation during movement (involuntary positional instability) and the ability to deliberately dislocate one's shoulder (voluntary instability) has been proposed.[41] Accordingly, the Gerber and Nyffeler classification distinguishes between patients who suffer from involuntary shoulder instability with voluntary reduction (type B6) and patients who can wilfully dislocate their shoulders (type C).[10] A further distinction between patients with voluntary instability who have the desire to dislocate their shoulders because of psychological or secondary gain issues (volitional instability) and patients who can deliberately dislocate their shoulders but have no actual desire to do so (demonstrable instability) has been emphasized.[27] Despite these existing classifications and descriptions of the pathology, a survey among shoulder experts identified voluntary shoulder instability (which can be considered as a former expression used for FSI) as the type of shoulder instability with the least agreement regarding diagnostic criteria.[7]

In a prospective descriptive study, FSI cases were clinically and radiologically analyzed in an attempt to provide a comprehensive and in-detail description of the characteristics of FSI. We hypothesized that FSI can be broken down into separate groups with distinct clinical findings.

Methods

Study cohort

All patients able to demonstrate what appeared to be a subluxation or dislocation mechanism of their shoulder during presentation at our outpatient clinic from January to December 2017 were included in this prospective cohort study. Local ethical committee approval was obtained prior to the beginning of the study and for all included minors, parental consent was obtained.

Information on a total of 38 consecutive cases was collected, including patient interviews with pathology-specific questionnaires, standardized clinical scores, clinical examination, video and dynamic fluoroscopy documentation of the pathomechanism, as well as magnetic resonance imaging (MRI). After review of all collected data, 2 patients were excluded from the study because of apparent initial misdiagnosis. One young female patient revealed scapular entrapment on biplane fluoroscopy imaging during arm elevation instead of the presumed repetitive glenohumeral instability. One middle-aged male patient with demonstrable anterior shoulder instability after a recent skiing accident showed an extensive acute glenoid fracture on MRI.

Clinical assessment

Before clinical examination, all cases completed a questionnaire on general medical history, pathology-specific medical history, and shoulder-specific activity level.[34] Standardized clinical scores including the Western Ontario Shoulder Instability Index,[26] Rowe Score,[39] as well as the Subjective Shoulder Value[12] were obtained. Furthermore, the pain level was rated on a numeric pain rating scale[13] at rest and in motion. All patients were asked to demonstrate their shoulder instability. Any macroscopic changes in the shoulder contour, abrupt shifts in shoulder position, or cracking noises were noted and video documented. Analysis of the presence of hyperlaxity included the sulcus sign,[23] which was rated positive if the sulcus exceeded 1 cm, the Gagey test,[9] which was deemed positive if glenohumeral abduction was more than 105°, as well as the Walch test,[8] which was considered positive in the presence of an external rotation >90°. In addition, the Beighton score[4] was used to determine generalized joint hyperlaxity. Scapular dyskinesis was diagnosed and classified according to Kibler et al.[24] Furthermore, active range of motion of the affected shoulders was assessed. Strength measurements were rendered impossible by the high grade of instability in a majority of patients.

Imaging

Fluoroscopy was employed in all cases to dynamically analyze the subluxation or dislocation process. The fluoroscope used for this study was a mobile C-Arm Ziehm 8000 (Ziehm Imaging Gmbh, Nuremberg, Germany). Before starting the procedure, the patients were positioned as close as possible to the fluoroscope wearing protection against radiation exposure. Next, the patients were asked to demonstrate their shoulder instability. Axial and anterior-posterior imaging was used to video document the presence and direction of instability. In the case of bilateral FSI with clinically identical appearance, only 1 side was analyzed with dynamic fluoroscopy in order to minimize radiation exposure.

Conventional MRI was obtained using a 1.5-Tesla system and a dedicated shoulder coil in all patients to identify any structural insufficiencies or sustained structural defects. In particular, all images were analyzed for the presence of rotator cuff lesions, muscle atrophy, muscle fatty degeneration, biceps tendon lesions, labral defects, cartilage defects, bony lesions, shape of the glenoid articular surface, and humeral head centering. In the case of bilateral FSI with identical clinical appearance, only 1 side was analyzed with MRI.

Types of instability

In a final reviewing process, video material and fluoroscopy imaging data of all collected cases were evaluated and, according to the observed pattern, different subtypes of FSI were determined and compared.

Two main types of FSI were distinguished and defined as positional FSI and nonpositional FSI. The term *positional FSI* was applied if a subluxation or dislocation of the shoulder occurred during motion of the arm (Fig. 1). In contrast, the term *nonpositional FSI* was applied if an apparent muscle contraction caused a subluxation or dislocation with the arm in neutral or close to neutral position (Fig. 2). Furthermore, the types of FSI were distinguished based on the patient's ability to willfully control the instability episodes.

Psychological assessment

Of the 25 patients included in the study, 22 (88%) participants agreed to screening for accompanying psychological disorders using the DSM-5 Self-Rated Level 1 Cross-Cutting Symptom Measure, a short but comprehensive psychological tool offered by the American Psychiatric Association. This self-administered questionnaire evaluates different specific mental health domains, such as depression, anger, mania, anxiety, etc and has shown good to excellent test-retest reliability.[1,38] Each domain is evaluated with questions regarding symptoms endured during the past 2 weeks to be rated on a 5-point severity scale (0 = none, 4 = severe). For minors, we used the adapted version DSM-5 Self-Rated Level 1 Cross-Cutting Symptom Measure–Child Age 11-17.[1] Patients reaching or exceeding the threshold mild (2), moderate (3), or severe (4) in the domain Somatic Symptoms were subjected to further investigation using the LEVEL 2–Somatic Symptom–Adult Patient or LEVEL 2–Somatic Symptom–Child Age 11-17.[1] These adapted versions of the commonly used Patient Health Questionnaire Physical Symptoms (PHQ-15) use 13 (children) or 15 (adults) different items to assess standardized somatic symptoms experienced during the last 7 days. The rating is accomplished on a 3-point scale (0-2). The level of somatic symptoms severity is interpreted as follows: minimal (0-4 points), low (5-9 points), medium (10-14 points), or high (15-30 points).

Statistics

After collection of data on spreadsheets, descriptive statistics were computed.

The Kolmogorov-Smirnov test was used to test the investigated parameters for normal distribution. The Mann-Whitney *U* test was employed for comparison of means of 2 unpaired samples and the Kruskal-Wallis test for comparison of means of more than 2 samples. For all analyses, the results were 2-tailed and the alpha level was set to 0.05.

Results

Patient characteristics

In total, 36 cases of FSI in 25 patients were collected. Fourteen patients (56%) presented with unilateral and 11 (44%) with bilateral FSI. Of the 25 patients, 16 were female (64%) and 9 male (36%). The mean age was 20 ± 5.2 years (range: 13-33 years), mean height 171 ± 9 cm (range: 150-190 cm), and mean weight 67 ± 15 kg (range: 45-110 kg). The mean shoulder activity level of patients having FSI was 1.1 ± 0.8 (range: 0-2). Hyperlaxity with combined positive sulcus sign, Gagey test, and Walch test as well as a Beighton score equal to or above 5, was noted in 36% of the cases (50% of controllable positional, 27% of noncontrollable positional, 75% of controllable nonpositional, and 50% of noncontrollable nonpositional FSI). Scapular dyskinesis was commonly noted with a prominent inferomedial border of the scapula (type I dyskinesis) presenting in 36% of the cases and a prominence of the entire medial border (type II dyskinesis) showing in 53% of all cases. Only 11% featured a normal scapulothoracic motion (3 cases of noncontrollable positional FSI and 1 case of controllable nonpositional FSI). Noticeable, general body posture of patients suffering from FSI often featured lumbar hyperlordosis, or thoracic hyperkyphosis as well as excessive protraction of the scapulae. The active range of motion of the affected shoulders displayed a mean flexion of 163° ± 31°, abduction of 157° ± 39°, external rotation of 70° ± 14°, external rotation in 90° of abduction of 69° ± 26°, internal rotation of Th9 ± 4, and internal rotation in 90° of abduction of 63° ± 25°.

In 72% of the 36 cases, no traumatic event was found as the cause of the first instability episode. In 28%, a minor trauma or repetitive micro-trauma performing high-demanding shoulder sports was reported as a triggering factor resulting in FSI. The mean age at which the first instability episode was experienced was 15 ± 5 years (range: 5-28 years). The mean time interval between the first instability episode and presentation at our department was 60 ± 52 months (range: 1-183 months).

Prior therapy consisted of conservative as well as surgical interventions. In total, 8 cases (22%) in 8 patients (32%) underwent unsuccessful surgical stabilization attempts, with 1 patient undergoing a total of 3 surgical procedures on 1 shoulder. Surgical interventions included arthroscopic capsulolabral shifts (n = 6), open capsulolabral shift (n = 1), Latarjet procedure (n = 1), rotator cuff tensioning (n = 1), and subacromial decompression for pain (n = 1). Sixty-nine percent of the cases had undergone physiotherapy for an extensive period of time with an average duration of 11.9 ± 14.5 months (range: 0.5-48 months). As symptoms persisted over an often extensive period of time without response to therapy, patients having FSI attempted several conservative treatment approaches,

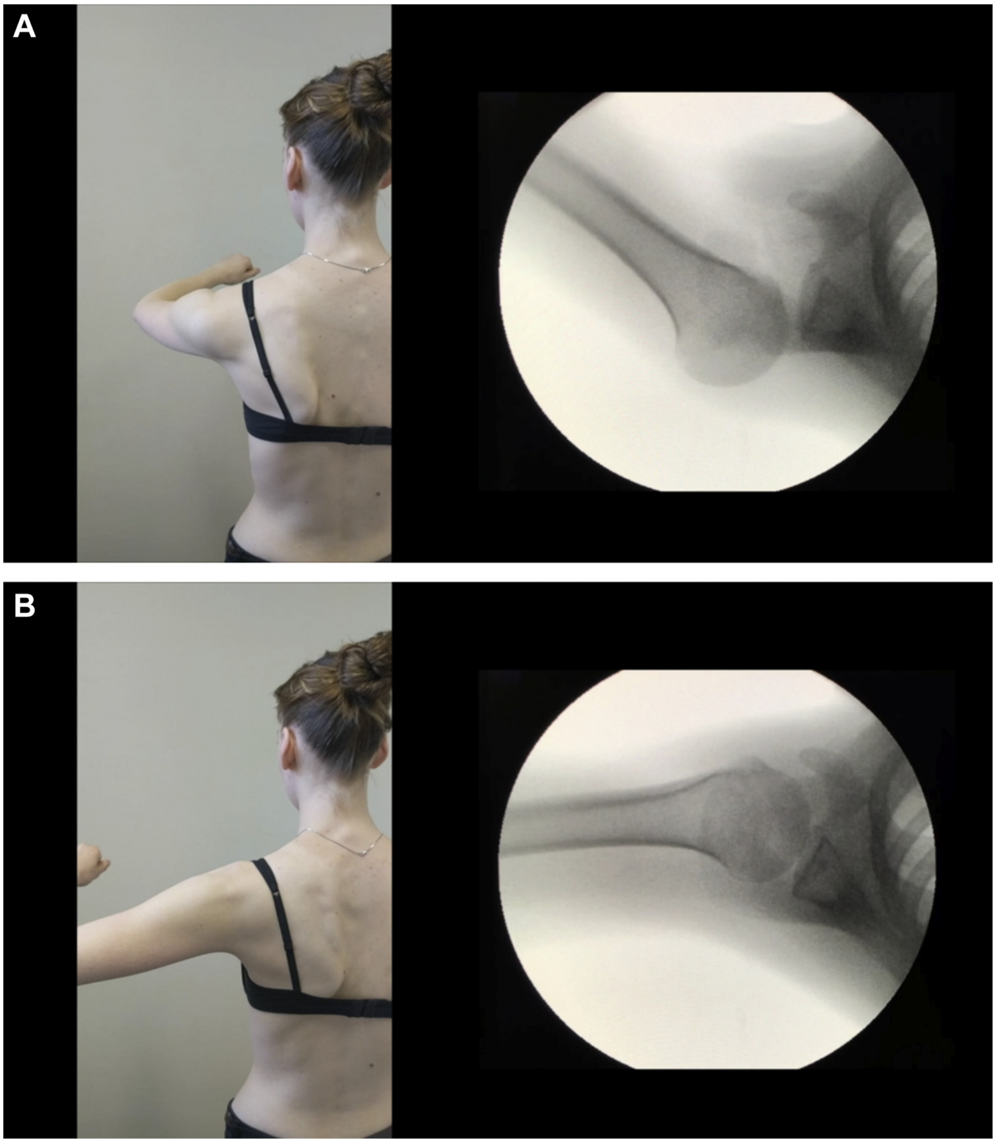

Figure 1 Clinical and fluoroscopic images of an adolescent woman with positional posterior functional shoulder instability. (**A**) Flexion and internal rotation of the arm lead to a temporary posterior dislocation of the humeral head visible as bulging of the posterior aspect of the shoulder. (**B**) Horizontal extension leads to reduction of the humeral head accompanied by abrupt contour normalization and sometimes also by a ''popping'' noise.

including training with resistance machines (42%), general physiotherapy (31%), manual therapy (31%), electrical therapy (25%), massage (25%), thermo-therapy (11%), and other conservative therapies (6%). Overall, 14% of the cases generally did not receive physiotherapy and in 17% only the shoulder with more prominent symptoms was treated although clinical evaluation clearly demonstrated a bilateral FSI.

Types of instability

Positional instability was more commonly observed (78%) than nonpositional instability (22%). In 3 patients, concurrent ipsilateral positional and nonpositional FSI was observed. Although in the positional group noncontrollable FSI (72%) was much more commonly observed than controllable FSI (6%), the frequency of nonpositional controllable (11%) and noncontrollable FSI (11%) was similar. Of all FSI cases, 78% showed a posterior instability, 17% an anterior instability, and 6% a multidirectional instability (Fig. 3).

The 4 different subtypes of FSI showed significant differences in all clinical scores (Western Ontario Shoulder Instability Index: $P = .002$; Rowe Score: $P = .001$; Subjective Shoulder Value: $P = .001$) and regarding their impact on functional impairment (shoulder stability: $P < .001$; daily activities: $P = .001$; sports activities: $P < .001$). Although overall the positional and the nonpositional

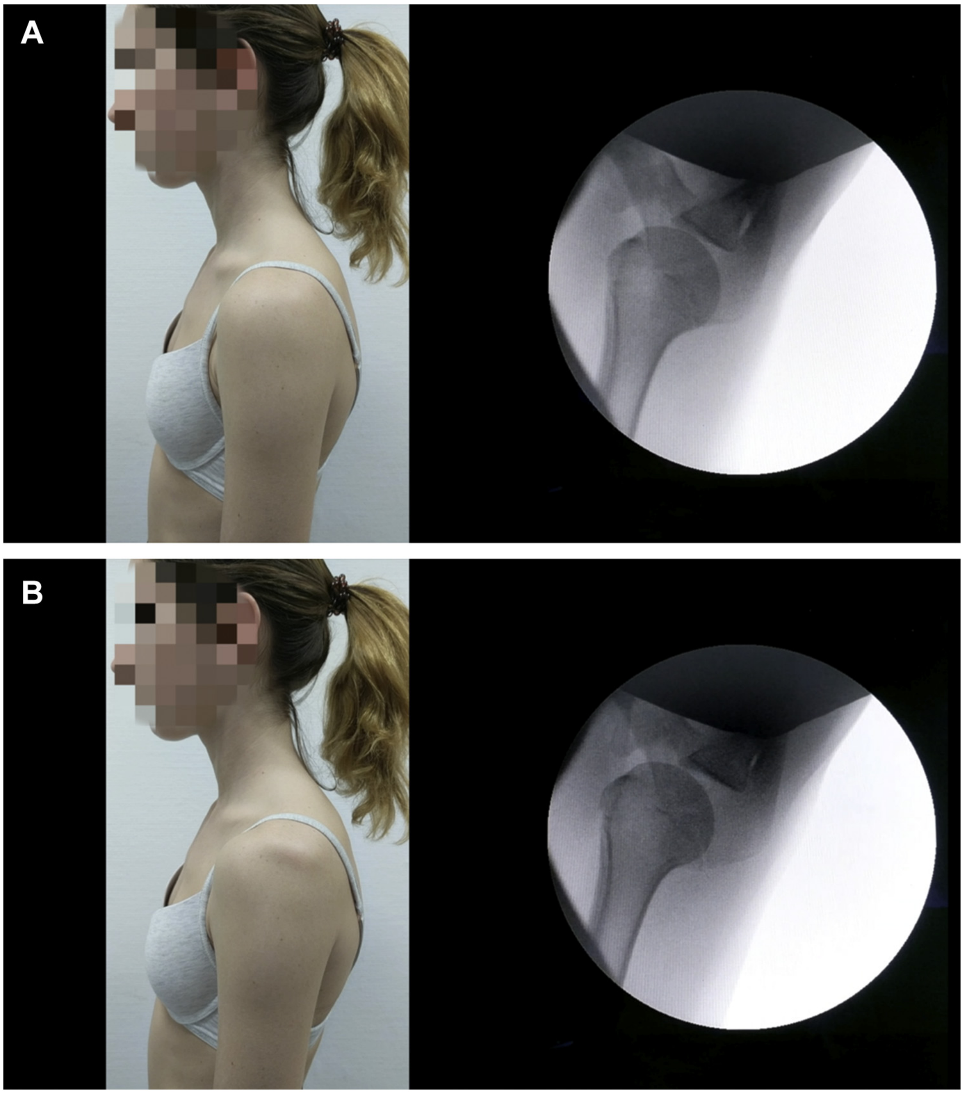

Figure 2 Clinical and fluoroscopic images of an adolescent woman with nonpositional anterior functional shoulder instability. (**A**) In neutral position of the arm, the humeral head is centered. (**B**) The patient can anteriorly subluxate the humeral head without moving the arm from neutral position. The subluxation becomes clinically apparent as a result of the sudden indentation underneath the acromion as well as the bulging of the anterior contour of the shoulder.

subtypes showed no statistically significant differences regarding clinical scores and functional impairment ($P >$ .09), there were significant differences between controllable and noncontrollable subtypes. The controllable types of FSI had only little impact on the clinical scores, whereas noncontrollable types of FSI showed significantly worse averages ($P < .001$) (Fig. 4). Regarding overall impairment of shoulder stability as well as impairment of daily activities and sports, a similar difference between controllable and noncontrollable types of FSI was observed ($P \leq$ .001) (Fig. 5). Noncontrollable nonpositional FSI showed a trend toward even worse scores and more severe impairment of shoulder function than noncontrollable positional FSI (Western Ontario Shoulder Instability Index: $P = .791$; Rowe Score: $P = .071$; Subjective Shoulder Value: $P = .044$; shoulder stability: $P = .007$; daily activities: $P = .536$; sports activities: $P = .157$).

No statistically significant difference regarding pain level at rest ($P = .932$) or during motion ($P = .597$) was noted between groups.

Radiological characteristics

The main structural deficiencies noted in this series of patients with FSI were changes of the morphology of the glenoid articular surface including glenoid flattening and glenoid dysplasia with soft tissue compensation (Fig. 6).

The mean overall recorded glenoid version was 96° ± 6° (range: 90°-120°), with an average of 92° ± 1.7° (range:

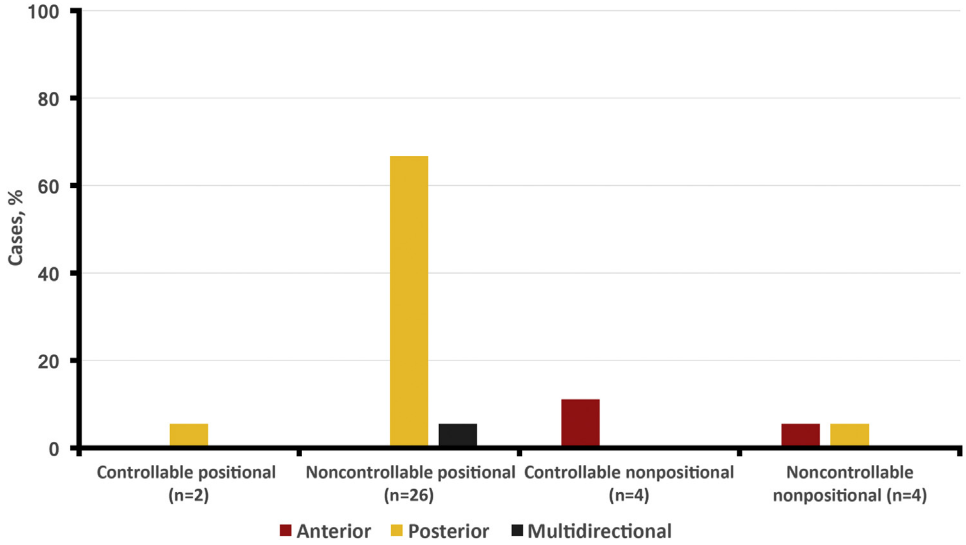

Figure 3 Subtypes of functional shoulder instability distinguished based on their pathomechanism, controllability, and direction of instability.

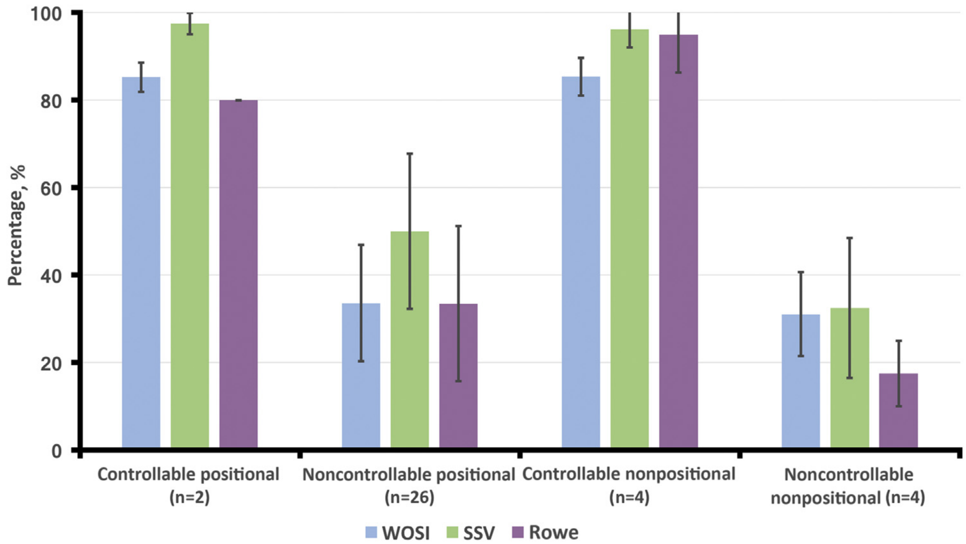

Figure 4 Average clinical scores recorded for the different subtypes of functional shoulder instability. *WOSI*, Western Ontario Shoulder Instability Index; *SSV*, Subjective Shoulder Value.

90°-94°) in patients with anterior FSI and an average of 97° ± 7° (range: 90°-120°) in patients with posterior FSI (P = .067). Sustained structural defects included 4 cases (16%) with slight labral lesions and 3 cases (12%) with small (reverse) Hill-Sachs lesions. None of the structural defects were of sufficient extent to explain the severe instability patients suffered from already during midrange or even starting-range of motion (Table I).

Psychological characteristics

Mean values in all the assessed mental health domains were elevated but low on average (Table II). Seven of 22 patients (32%) exceeded the defined threshold in the domain Somatic Symptoms and were subjected to further evaluation. Assessment of Level 2–Somatic Symptom displayed minimal or low severity of somatic symptoms in 6 patients (27%), and 1 patient (5%) reached medium severity.

Discussion

Functional shoulder instability is a condition mainly caused by pathologic muscle activation patterns instead of structural defects. In this prospective study, a detailed description of the characteristics of FSI and its different subgroups was provided.

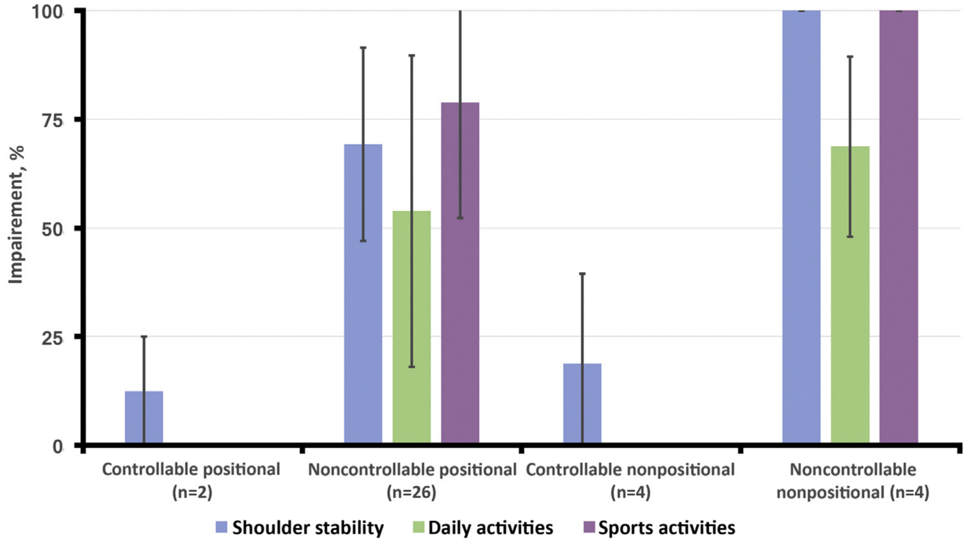

Figure 5 Average impairment of shoulder stability, daily activities, and sports activities among the different subtypes of functional shoulder instability.

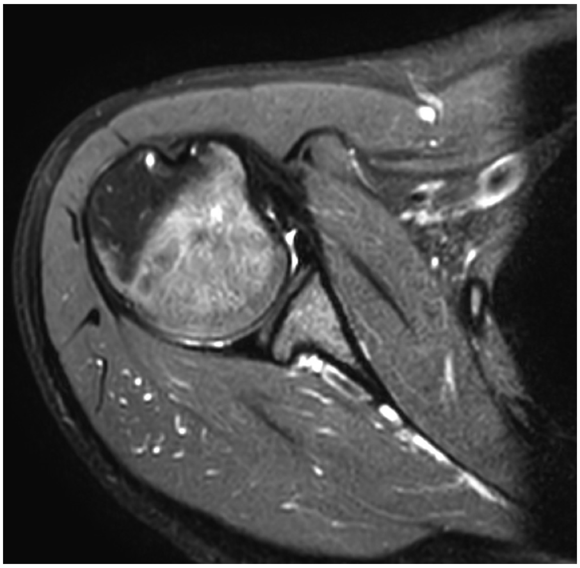

Figure 6 Axial magnetic resonance image of a patient with functional shoulder instability and associated glenoid dysplasia with convex shape of the articular surface of the glenoid.

Based on the findings of this study, we propose the following classification of FSI (Fig. 7) (Video 1).

Positional FSI involves subluxations or dislocations caused by movement of the affected arm in a certain position and spontaneous reduction once the position is left again. Positional FSI can either be controllable or noncontrollable. Controllable means that subluxations or dislocations can voluntarily be caused by the patients by executing certain movements. It creates little discomfort or functional impairment because it can be suppressed by the patient if wanted. Noncontrollable means that subluxations or dislocations occur involuntarily during movement of the arm. It can lead to severe loss of function, discomfort, and pain because it cannot be countered by the patient. The typical movement during which posterior positional FSI can be observed is horizontal flexion and internal rotation. It causes a posterior subluxation or dislocation, which, for the observer, is often hardly noticeable. Subsequent horizontal extension leads to reduction of the joint, which is typically visible for the examiner as a result of an abrupt contour change of the posterior aspect of the shoulder sometimes accompanied by a ‘‘popping’’ noise (Fig. 1). The typical movement during which anterior positional FSI can be observed is abduction and external rotation. The movement causes a subluxation or dislocation of the humeral head, which is visible as bulging in the axilla. Reduction is obtained by returning to a neutral position. Posterior positional FSI was by far the most commonly observed type of FSI in this study. Anterior positional FSI seems to be much less frequent.

Nonpositional FSI involves subluxations or dislocations of the shoulder in neutral or close to neutral position of the arm. In contrast to positional instability, it is not caused by certain arm movements but rather seems to be caused by pathologic muscle contractions that lead to a temporary dislocation of the humeral head (Fig. 2). This form of FSI also can be controllable or noncontrollable. In the case of a controllable nonpositional FSI, patients often have no functional impairment. In contrast, noncontrollable nonpositional FSI is a very severe form of shoulder instability that can completely impair normal shoulder function. Repetitive subluxations, dislocations, or sometimes even static dislocations in various directions are sustained even with the arm in neutral rotation because of nonphysiological muscle contractions, and in some cases ‘‘tic-like’’ muscle contractions are observed. Although both anterior and posterior nonpositional FSI exist, the anterior direction can

Table I Structural deficiencies and defects observed on MRI scans of patients with functional shoulder instability

Structural deficiency or defect	n (%)
Rotator cuff lesions: muscle atrophy or fatty degeneration	0 (0)
Biceps tendon lesions	0 (0)
Cartilage lesions	0 (0)
Labral damage	4 (16)
Bony glenoid defect	0 (0)
(Reverse) Hill-Sachs lesion	3 (12)
Shape of articular surface	
Concave	20 (80)
Flat	3 (12)
Convex	2 (8)
Glenoid dysplasia	
With soft tissue compensation	6 (24)
No compensation	0 (0)
Decentered humeral head	2 (8)

MRI, magnetic resonance imaging.

Table II Results of the mental health issue screening of the patients using the DSM-5 Self-Rated Level 1 Cross-Cutting Symptom Measure

Level 1 domain	Adult, Mean (SD) (n = 16)	Child, Mean (SD) (n = 6)
Depression	0.56 (0.79)	0.08 (0.28)
Anger and irritability	0.44 (0.5)	0.25 (0.43)
Mania	0.84 (1.42)	0.25 (0.43)
Anxiety	0.69 (1)	0.11 (0.31)
Somatic symptoms	0.63 (1.05)	1 (1.15)
Suicidal	0.19 (0.73)	0%*
Psychosis	0.06 (0.24)	0 (0)
Sleep problems	0.94 (1.3)	0.5 (1.12)
Memory	0.31 (0.58)	—†
Repetitive thoughts and behaviors	0.5 (1.03)	0.17 (0.47)
Dissociation	0.13 (0.48)	—†
Personality functioning	0.19 (0.58)	—†
Substance use	0.33 (0.94)	17%*
Inattention	—†	0.83 (1.21)

DSM-5, Diagnostic and Statistical Manual of Mental Disorders, 5th edition; *SD*, standard deviation.
Means (SDs) are presented for the child and adult version.
* Mean (SD) is not provided because the answer is *yes* or *no*.
† Only part of the questionnaire for adults or child.

be observed more commonly, especially in patients with controllable nonpositional FSI.

An important factor in FSI is the burden and perception of disease. Patients with controllable positional or nonpositional FSI often do not have any symptoms and therefore do not interpret their "condition" as pathologic but rather as an enhanced ability. Therefore, it is likely that many patients with controllable FSI do not even seek medical attention, which is also the reason why patients with controllable FSI are surely underrepresented in this study. As a matter of fact, some adolescents were presented to us because their parents worried about their child's "abnormal" shoulder movements rather than because of actual symptoms of the patient. The perception of this form of FSI can vary extensively. It ranges from the positive interpretation as delightful party trick maneuver to the negative interpretation as attention-seeking behavior.[27] In contrast, patients with noncontrollable positional or nonpositional FSI often carry a large burden of disease in terms of severe loss of function, discomfort, and pain. Many patients in this study had visited several medical specialists before consultation at our institution and had undergone extensive periods of physiotherapy and even surgical stabilization attempts without success. This lack of successful previous therapy paired with an extensive medical record is sometimes interpreted as doctor shopping, attention-seeking behavior, or even an underlying psychiatric disorder.[10,16,27] However, attention must be paid not to be lured into a premature labeling of these patients as psychiatric by the combination of their "freakish"-looking symptoms, the absence of relevant structural defects, and the ineffectiveness of multiple forms of treatment. According to our results, no severe mental health disorder could be found in these patients, and the conspicuous minor findings, in our opinion, might be explained by the severe burden of the pathology itself, which affects the often adolescent patients not only physically but also psychologically in this very vulnerable period of character development.

Fluoroscopy helped to objectively assess the direction of instability. Although multidirectional instability might have falsely been suspected in the clinical examination, in most patients with FSI a unidirectional instability was revealed. Especially in the large group with positional FSI, posterior was by far the most common direction of instability. Anterior and anteroinferior FSI was mostly observed in the group with nonpositional FSI. Only 1 patient with positional FSI showed a true multidirectional instability in the anterior and posterior direction. Therefore, true multidirectional instability seems to be less common among patients with FSI than expected. Surprisingly, one patient with clinically suspected positional FSI revealed no glenohumeral instability during fluoroscopy but rather a form of entrapment of the scapula within the periscapular musculature instead. The case might represent a very rare form of FSI in a wider sense but does not represent glenohumeral FSI. However, it is noteworthy that in 89% of the examined patients with FSI an accompanying scapular dyskinesis was noted during clinical examination. Although we cannot distinguish whether the dyskinesia is the cause or the consequence of FSI, it certainly seems to play an important role in its treatment.[20]

Structural insufficiencies and, even more so, structural defects are a much debated topic in patients with FSI. Although structural insufficiencies such as altered

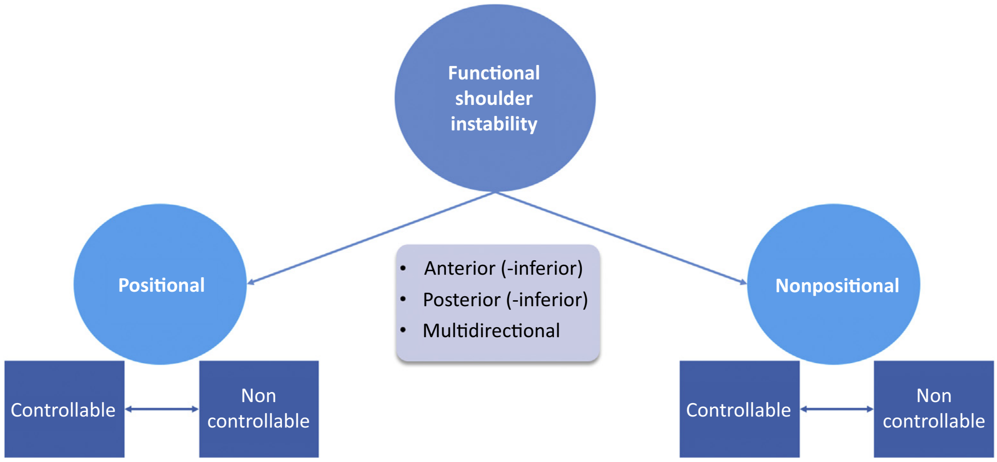

Figure 7 Classification of functional shoulder instability based on pathomechanism (positional and nonpositional) and controllability (controllable and noncontrollable).

morphology of the glenoid articular surface or generalized soft tissue hyperlaxity was encountered in several patients of this study cohort and likely contributed to their symptoms, the extent of the causal relationship is yet unclear. Additionally, it is unclear whether the observed shape variations of the glenoid are purely constitutional or a consequence of altered muscle forces and vectors influencing skeletal development during early childhood.[25] Obtained structural defects, on the contrary, were rarely observed in these patients and, if present, they were of minor extent. These small defects do not have enough biomechanical effect to cause the severe instability in midrange or even starting-range of motion observed in the patients and, therefore, rather seem to be a consequence of the repetitive instability episodes. In general, it is remarkable how rarely structural defects and degenerative changes are observed in patients with FSI despite an extremely high number of recurring instability episodes. This is likely explained by the pathologic muscle activation pattern leading to very low concavity compression forces acting during subluxation or dislocation. Interestingly, during the study period, one patient with extensive traumatic structural defect was initially misdiagnosed with functional shoulder instability because of the demonstrable nature of his instability before MRI scans were obtained. In general, it is recommended to perform an MRI scan in every patient before locking in on the diagnosis of FSI.[32,36] At the same time, it is important not to overinterpret minor structural lesions seen on MRI that are not able to explain the severe form of shoulder instability patients display during clinical examination in order to avoid unnecessary surgical interventions with often unsatisfactory and in some cases even catastrophic outcome.[15,17,20,28,32,36,41]

The presumed cause for positional as well as nonpositional FSI is an imbalance of muscle activation patterns.[14,22] In the group of patients with positional FSI, hypoactivity of certain rotator cuff muscles appears to lead to excessive translation of the humeral head during movement of the arm. Although hypoactivity of the infraspinatus muscle as well as the teres minor muscle can result in posterior instability, hypoactivity of the subscapularis muscle seems to lead to anterior instability. This can, for example, explain why the wall-slide maneuver (resisted external rotation during arm elevation)[11,20] stabilizes the shoulder in patients with positional posterior FSI. Nonpositional FSI appears to be caused by hyperactivity of larger muscles, which pull the humeral head out of its physiological position. For example, anterior or anteroinferior nonpositional FSI seems to be caused by excessive contraction of the pars abdominalis of the pectoralis major muscle,[40] while possibly overactive large internal rotators such as the latissimus dorsi muscle and teres major muscle cause posterior or posteroinferior instability of the humeral head. Although some electrophysiological evidence[3,18,19,22,37] supports these assumptions drawn from clinical observation, further electrophysiological analysis is required to precisely determine which combination of muscle hypo- and hyperactivity is responsible for the different types of FSI.

Unfortunately, it is not possible to offer clear treatment recommendations for the different subtypes of FSI because very few clinical studies are reported. Those that are reported differ widely regarding diagnosis, classification, and treatment, which is a general challenge with this rather complicated pathology.[7] Nonetheless, a few principles that have provided treatment success in the past ought to be mentioned. First of all, patients with controllable FSI should neither be treated surgically nor conservatively as they have not lost control over the stability of their shoulders and are unlikely to develop any secondary degenerative changes.[10] Patients with noncontrollable FSI should not undergo surgical treatment, because of the unpredictable outcome.[15,17,20,28,32,36,41] As the pathology might be self-limiting and disappear over the course of several years, skillful neglect has been proposed as a treatment alternative.[17,28] However, this long-term approach with unguaranteed outcome is hardly accepted by the often young patients who want and need to regain function quickly. Quite often, patients affected by FSI visit several medical professionals in the search for alleviation of their symptoms and after years of unsuccessful conservative treatment, eventually undergo a salvage surgical stabilization attempt with sometimes worse outcome than prior to surgery. Therefore, it is key to provide a targeted conservative treatment including core stabilization, coordination exercises, strengthening, and biofeedback.[20,41] For the large group of patients with positional posterior FSI, promising preliminary results have been obtained with a therapy concept based on electric muscle stimulation.[33]

Limitations and strengths

As explained above, patients with controllable FSI are less likely to seek professional medical assistance than patients with noncontrollable FSI. Therefore, the ratio between controllable and noncontrollable FSI presented in this study does not reflect reality but rather a clinical reality seen from the referral center's perspective. Generally, the true prevalence of FSI and its subtypes remains unknown and is likely higher than expected.[30]

A further limitation is the fact that in the case of bilateral symmetric appearance of FSI, dynamic fluoroscopy and MRI examinations of only 1 side were obtained in order to limit radiation exposure, duration of examination, and study costs.

Moreover, a surface electromyography analysis to detect abnormal muscle activation patterns has been attempted in this patient cohort but was unsuccessful because the surface electrodes were not able to procure measurements of sufficient quality, probably because of the rapid change in motion during instability episodes. A similar limitation of surface electromyography in detecting abnormal muscle activation patterns in FSI has been described by Jaggi et al.[21]

This study is the first comprehensive and in-depth prospective diagnostic analysis of a rather large case series of patients with FSI providing clinical examination with video documentation as well as MRI and dynamic fluoroscopy imaging in order to identify different subtypes of FSI and their characteristics. The findings of this study may serve as a starting point for future systematic exploration and discussion of much needed treatment options.

Conclusions

FSI can be classified into 4 subtypes based on pathomechanism and controllability. Depending on the subtype, patients show different degrees of functional impairment. In most patients with FSI, unidirectional instability can be observed with the majority of patients having posterior FSI. Although several patients show accompanying structural insufficiencies including generalized soft tissue hyperlaxity or altered morphology of the glenoid articular surface, structural defects are typically absent or of minor extent.

Disclaimer

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Supplementary Data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jse.2019.05.025.

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