Indoor Skydiving: An Emerging Cause of Anterior Shoulder Dislocations

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Background: The risks of indoor skydiving have not been extensively studied. Indoor skydiving facilities are often used for corporate events and parties and by relatively inexperienced participants who may not appreciate the risks involved. The abducted and externally rotated shoulder position, combined with nearby walls, tight spaces, and the strong airstream, has resulted in a pattern of shoulder dislocation injuries.

Case Report: A 26-year-old male presented with recurrent left shoulder instability after developing an engaging Hill-Sachs lesion following traumatic anterior shoulder dislocation while indoor skydiving. He entered the wind tunnel with his arms abducted and externally rotated. The wind created an upward force that held his arms in this position. As he reached for the side of the tunnel to exit, his arm was forced into further external rotation, dislocating the shoulder. The patient was treated arthroscopically with a remplissage procedure and repair of the glenoid labrum. Postoperatively, he resumed his active lifestyle and sports without further dislocations or instability.

Conclusion: Indoor skydiving may pose a high risk of anterior dislocation because the shoulder is forced into abduction and external rotation in the free-fall position. We advise caution before participation in indoor skydiving by any individual, but especially those with a history of shoulder instability.

Keywords: Athletic injuries, Bankart lesions, labral injuries, shoulder dislocation

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INTRODUCTION

Patients characteristically at risk for anterior shoulder dislocation tend to be males aged 18 to 29 years who participate in contact sports or undergo military training.1-3 Anterior shoulder dislocations also occur in association with the sport of skydiving and are often attributed to the airstream force on the arm. In skydiving, the arms are abducted and externally rotated, and the airstream pushes the arms into further external rotation.4,5 This position aligns with the accepted mechanism of anterior shoulder dislocation.6

Skydiving has evolved into an indoor version in which a powerful fan blows air upwards to suspend the participant in an enclosed column. Advocates have pushed to make indoor skydiving an Olympic event.7 However, indoor skydiving facilities are often used for corporate events and parties and by relatively inexperienced participants who may not appreciate the risks involved. The abducted and externally rotated shoulder position, combined with nearby walls, tight spaces, and the strong airstream, has resulted in a pattern of shoulder dislocation injuries. Rodrigues reported that 61 of 120 (51%) injuries at a skydiving company occurred to the shoulder and ranged from pain to dislocations.8

We present a case of anterior shoulder dislocation that occurred during indoor skydiving.

CASE REPORT

A right-handed, 26-year-old male presented with recurrent left shoulder dislocations resulting in severe shoulder instability. He had initially dislocated his shoulder while indoor skydiving approximately 2 years prior to this consultation. He entered the wind tunnel with his arms abducted and externally rotated, and the airstream created an upward force that held his arms in position. While attempting to exit, he reached for the side of the tunnel with his left arm, and the arm was forced into further external rotation by the airstream. The patient felt his shoulder dislocate and then spontaneously relocate seconds later (Figure 1). He had had no shoulder injuries prior to the initial dislocation. After the dislocation, the patient completed extensive nonoperative rehabilitation that involved several months of physical therapy at the direction of an emergency department physician. Approximately 1 year later, the patient dislocated his shoulder a second time when he collided with another player while playing soccer. He again pursued physical therapy; however, his shoulder continued to dislocate with...
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Figure 1. Illustration demonstrating the mechanism of shoulder dislocation. The patient is in the wind tunnel with his arms abducted and externally rotated, with the wind pushing his arms into further external rotation. When he reached for the side of the wind tunnel while attempting to exit, his left arm was forced into further external rotation, causing an anterior dislocation of the left shoulder. (Original art by Daniel M. Zumsteg, MD. Published with permission.)

Increasing frequency and minimal force, including during sleep.

Clinically, the patient's left shoulder was highly unstable, with apprehension at 60° of forward flexion and 30° of external rotation. He had a positive Jobe relocation test and sulcus sign, both indicating shoulder instability. The patient had no signs of systemic ligamentous laxity at the elbow or thumb. With a stabilizing posterior push, he exhibited bilateral shoulder flexion to 175° (normal flexion, 165°) and external rotation in full adduction to 95° bilaterally (normal rotation, 90°). He was tender over the left proximal biceps. He had mild pain and weakness with the empty can test, Speed test, and O'Brien test, indicating possible superior rotator cuff injury, injury to the long head of the biceps or superior glenoid labrum, and glenoid labrum injury, respectively. The lift-off test was normal, indicating an intact subscapularis. Sensory and vascular examinations were normal. The patient's medical history was negative for medications, tobacco, alcohol, and recreational drug use.

Closed 3 Tesla magnetic resonance imaging of the patient's left shoulder without contrast completed 5 days after the orthopedic evaluation showed a 270° labral tear, including a superior labrum anterior-to-posterior lesion extending into the biceps anchor, an anterior inferior glenoid Bankart labral tear with capsular injury, and a posterior inferior labral tear. Only the posterior superior labrum remained attached to the glenoid. A type II to type III acromion was also visualized, with associated rotator cuff tendinosis. Noncontrast computed tomography scan of the left shoulder showed mild compression of the anterior glenoid fossa with preservation of the glenoid surface area over a 1.1-cm area (Figure 2). A Hill-Sachs deformity measuring 1.4 cm × 0.3 cm was visualized (Figures 2, 3, and 4).

The patient was scheduled to undergo arthroscopic left glenoid labrum repair and remplissage procedure to treat his recurrent shoulder dislocations and associated structural injuries. The patient played soccer 2 days before his scheduled surgery and had another dislocation. The shoulder remained dislocated for several hours until it was reduced in the emergency department, potentially enlarging the Hill-Sachs lesion.

Surgical intervention with the patient under general anesthesia included a remplissage procedure, repair of the glenoid labrum, capsular plication, debridement, and acromioplasty. The shoulder demonstrated significant instability, dislocating with anteriorly directed force while in the neutral position. Forward flexion to 30° in neutral rotation also caused the shoulder to dislocate (Figure 5). Diagnostic arthroscopy demonstrated a 270° labral tear with only the posterior labrum intact, as well as a large and
Figures 2, 3, and 4 illustrate computed tomography scans and a three-dimensional reconstruction of the left shoulder, showing various lesions and their surgical implications.

**DISCUSSION**

Understanding the risks involved with indoor skydiving is important, especially with expansion of the sport and the campaign to add it to the 2024 Olympic Games. The airstream force and body position of indoor skydiving have the potential to dislocate the shoulder. This mechanism has been studied and described in outdoor skydiving. In a 2007 analysis of outdoor jumps in Sweden, 3 of 7 injuries sustained during free fall were shoulder dislocations caused by the force of the airstream, with an additional 7 dislocations occurring during the rest of the jump. However, shoulder injuries accounted for only 3.9% to 4.8% of the total outdoor skydiving injuries documented in Sweden between 1999 and 2003 and at the 2000 and 2001 World Freefall Convention in Illinois. This rate of shoulder injury may increase dramatically when the sport is brought indoors, with one author...
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Figure 5. Arthroscopic image within the shoulder joint shows the humeral head dislocating while in 30° of forward flexion and neutral rotation.

indicating that 51% of reported injuries involved the shoulder joint.8 These data suggest that the indoor variant of skydiving may provide additional risk of traumatic shoulder injury or dislocation compared to outdoor skydiving.

Hill-Sachs lesions are distinct osseous defects in the head of the humerus and are typically caused by traumatic anterior shoulder dislocations.5 The relatively soft posterolateral aspect of the humeral head forcefully collides with the harder anterior bone of the glenoid rim, leading to the characteristic posterolateral humeral compression fracture known as a Hill-Sachs lesion.10 Of patients with chronic anterior shoulder instability, 93.3% were found to have Hill-Sachs lesions upon arthroscopic investigation.11

In our case, the severe instability of the patient’s shoulder, notable bone loss, and recurring nature of his dislocations indicated that arthroscopic labral repair and capsular plication alone would have been insufficient in resolving his symptoms.12 Both a coracoid bone transfer to the glenoid (Latarjet procedure) and remplissage procedure were considered in addition to labral repair.13,14 While both the Latarjet and remplissage procedures have comparable clinical outcomes, the remplissage procedure has a lower complication rate in the setting of subcritical glenoid bone loss. The specific technique used in our case is similar to that described by Purchase et al., using an arthroscopic remplissage and Bankart to stabilize a shoulder with glenoid bone loss and a large Hill-Sachs lesion.15

This case elucidates a previously undescribed mechanism and setting of shoulder dislocation, in which the participant is already in the vulnerable abducted and externally rotated position in the wind tunnel and reaches for the stationary tunnel wall, forcing the arm further into external rotation and dislocating the shoulder. As indoor skydiving becomes more accessible and popular, physicians and participants alike must understand the risks, particularly when shoulder dislocations may have a disproportionately increased prevalence compared to other injuries such as neck strain or knee injuries. While the injury-per-jump numbers of outdoor skydiving are known (ranging from 48 injuries per 100,000 jumps to 174 injuries per 100,000 jumps), the injury rate for indoor skydiving is not well established.4,9 Studies of injuries associated with indoor skydiving are an important next step in evaluating the safety of the sport.

CONCLUSION

Indoor skydiving may predispose participants to anterior dislocations because an already-abducted shoulder can be forced into hyper-external rotation. In this case, we presented the mechanism and setting of anterior shoulder dislocation that was treated arthroscopically with labral repair, capsular plication, and remplissage procedure. The patient made a complete recovery from a debilitating injury without any loss of range of motion. We advocate consideration of the remplissage procedure for engaging Hill-Sachs lesions and advise caution before participation in indoor skydiving by any individual, but especially those with a history of shoulder instability.

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