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The shoulder in the collision athlete

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Abstract

"Collision athletes" participate in sports and activities that involve regular impact with opponents. In our community in New Zealand, the most common "collision" sports are rugby union and rugby league. Combat sports such as boxing and martial arts are also collision sports. Injuries are common in the collision athlete, especially shoulder injuries. There are many different injury mechanisms and patterns of shoulder injury that arise from collision impact. As power and muscle mass are an advantage in collision sports, these athletes often participate in heavy weight-training and may sustain shoulder injuries related to sport-specific conditioning. There are many factors to consider in the management of shoulder injuries in the collision athlete. The short-term and long-term effects of injury and treatment options, season and career timing, non-operative and operative treatments must all be considered. Player safety should be paramount. With good treatment, the expectation of most elite athletes with collision shoulder injuries is that they will return to their sport. Athletes nearing retirement and recreational collision athletes may prefer to minimise re-injury risk by retiring from collision sports, even after successful treatment. The preventative strategies and long-term consequences of collision shoulder injuries have not been defined.

Keywords athletic injuries; physical examination; shoulder; shoulder dislocation; surgery

Epidemiology of shoulder injuries in the collision athlete

Collision shoulder injuries may occur during competition or during training and result in significant disruption to the career of a professional athlete. A recent report concerning professional rugby players found that shoulder injuries were the most common reason for retirement due to injury in the previous 10 year period, accounting for 8 of 33 (24%) retirements (first equal with cervical spine injuries).[1] In professional English rugby union players the shoulder is reported to be the 2nd most common injury site for backs and the 5th most common for forwards.[2] Injuries include acromioclavicular (AC) joint injuries and glenohumeral instability patterns, including traumatic dislocations and rotator cuff injuries. Glenohumeral dislocations are the second most common cause of lost days from sport in rugby union backs and 3rd most common for forwards.

Recent injury surveillance data from the England Rugby Premiership indicated that one third of all injuries for the 2011–2012 season occurred during training.[3] For shoulder injuries sustained in training, the AC joint is reported to be the most commonly injured region in the shoulder and glenohumeral dislocations are the main cause of lost playing days resulting from shoulder injuries.[1,3] The most common situation in which shoulder training injuries occur is when practicing defence drills. As defence becomes an increasingly important part of rugby, and specialist coaches become involved, there is more contact in training, increasing the risk of collision injuries. Table 1 summarises the key points from the literature on rugby shoulder injuries, regarding match and training injuries, player position variations, the mechanisms, nature and severity of injuries.

We surveyed a professional New Zealand provincial rugby team for shoulder injuries. This team included entry-level professional rugby players and players who also play at international level. 24 players (48 shoulders) completed Oxford Instability Scores. 80% of the players had already had surgery for injuries sustained playing rugby, and more than half of the players (56%) had already had shoulder surgery for an injury sustained through rugby. Approximately 60% of the forwards and 40% of the backs had already had shoulder surgery for a rugby injury. Two thirds of the players recalled losing game time in their career as a result of shoulder injury. Shoulder surgery procedures included glenohumeral stabilisation, pectoralis major repair, AC joint surgery and arthroscopic debridement (Figure 1). The Oxford Instability Score has a maximum score of 48, representing a perfect (asymptomatic) score. In the team survey, the mean Oxford instability scores after the different types of shoulder procedures reported was more than 40/48 for most players. Players who had previously undergone a glenohumeral stabilization procedure had a mean score of 45/48. It should be noted however that numbers in different diagnostic groups was small. Interestingly, many players reported some symptoms in the shoulders that had not had surgery (Figure 2). An additional nine players were not available to participate in the study, with most of these players being away on international duties. Of these nine players at least seven had undergone previous surgery for rugby injuries, at least two had shoulder surgery and another was convalescing with non-operative treatment after recent shoulder injury.

In Rugby League there is a similar high prevalence of shoulder injuries in New Zealand. Injuries are registered and treated by the national injury insurer, the Accident Compensation Corporation (ACC). King et al. found that, according to ACC data, the shoulder was the second most frequent and third most costly injury in rugby league in New Zealand between 1999 and 2007.[4] Of all rugby league related injury claims, 15% were soft tissue shoulder injuries and 21% were shoulder fractures or

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Incidence, prevalence and nature of shoulder injuries in rugby union

	Match		Training	
	Backs	**Forwards**	**Backs**	**Forwards**
Incidence of shoulder injuries	Shoulder 2nd most common match injury in backs.	Shoulder 5th most common match injury in forwards.		
Most common shoulder Injuries	• AC joint • GHJ dislocation • Cuff/impingement	• AC joint • GHJ dislocation • Cuff/impingement	• AC joint • GHJ dislocation • Cuff/ impingement	• AC joint • GHJ dislocation • Cuff/impingement
Injury Severity (lost days)	• GHJ dislocation: ○ Most severe shoulder injury (time lost) ○ 2nd rank of all injuries • Cuff/impingement • AC joint	• GHJ dislocation: ○ Most severe shoulder injury (time lost) ○ 3rd rank of all injuries • Cuff/impingement • AC joint	• GHJ Dislocation	• GHJ Dislocation
Mechanism	• "Try Scorer" (hyper-flexion) • "Tackler" (horizontal abduction) • Direct Blow (arm by side/in adduction)		Defence drills	Ruck and maul/defence drills

Abbreviations: AC, acromioclavicular; GHJ, glenohumeral joint.
(Brooks, Fuller, Kemp, & Reddin, 2005; J Crichton, D. R Jones, & L Funk, 2012; C. W Fuller, F Laborde, R. J Leather, & M. G Molloy, 2008).

Table 1

dislocations. The cost to the ACC for shoulder injuries during this period was NZD $6,856,788.[4] These costs include investigation, treatment and some earnings-related compensation.

Usman and McIntosh, conducted a prospective cohort study across five rugby seasons, involving 1475 adult male players in colts (younger age group), grade and elite competitions.[5] They found a lower incidence of shoulder injuries in the elite players compared to the colts and grade players. The shoulder injury incidence rate per 1000 athletic exposures was 3.57 in the elite group, 6.61 in the grades group and 7.14 in the colts group. Glenohumeral dislocations were more common in the elite group and AC joint injuries were more common in the colts and grade players. In elite and grade players the tackler was more

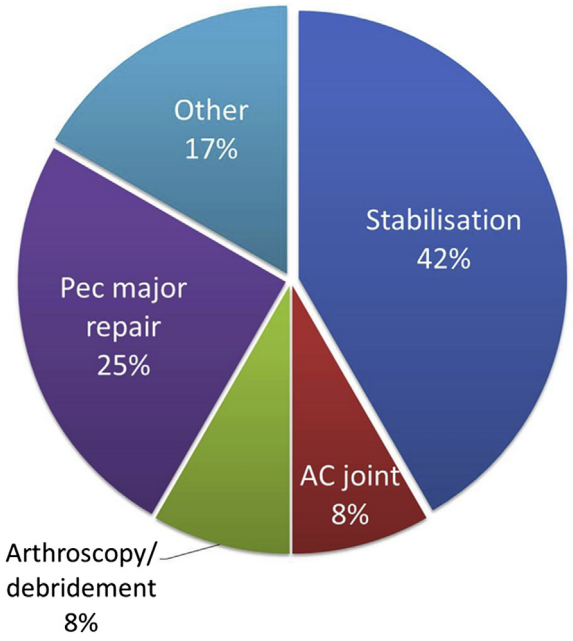

Figure 1 Previous shoulder surgery reported by players in a provincial rugby union team. (n = 12).

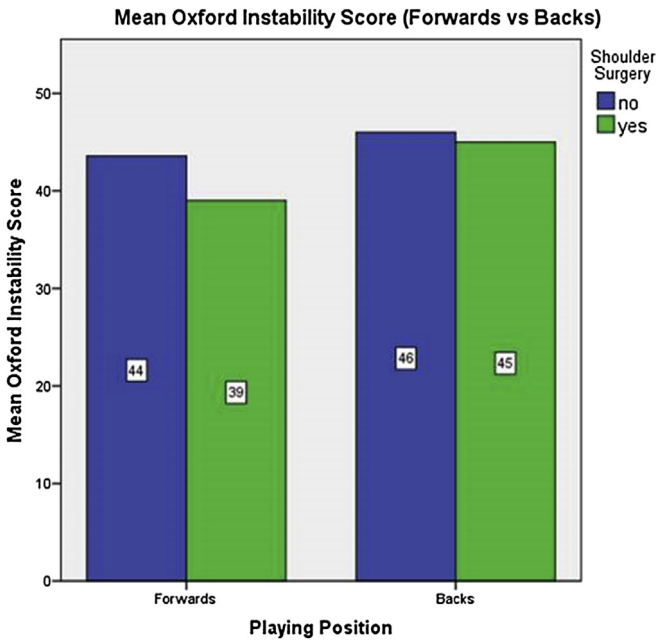

Figure 2 Mean Oxford Instability Scores among provincial rugby players. (n = 11).

commonly injured, whereas the players being tackled were more commonly injured in the younger, colts group.

Nature and mechanism of injury

Some aspects of injury and the injury mechanisms have been discussed in the previous section. Crichton, Jones and Funk examined video recordings of 24 elite rugby players sustaining shoulder injuries during games.[6] Some of their findings are summarized in Table 2. They described three common injury mechanisms in elite rugby union players; the "Try scorer", the "Tackler" and the "Direct impact".

The "Try scorer" involves a hyper-flexion force of the outstretched arm. This may occur at speed with the player diving forward, scoring a try and can be accentuated when a tackler lands on the posterior shoulder, forcing it further into hyper-flexion. With this mechanism, players may sustain glenohumeral dislocations, labral tears and/or rotator cuff tears.

The "Tackler" mechanism of injury involves forceful extension of the abducted arm of the tackler's shoulder. With this mechanism, players may sustain glenohumeral dislocations and labral tears. The "Direct blow" mechanism involves a forceful compression of the players shoulder with the arm at the player's side in a neutral or adducted position. With this mechanism, players may sustain glenohumeral dislocations, labral tears, AC joint injuries and scapular fractures.

Most rotator cuff injuries were seen with the "Try scorer" mechanism and most AC joint and scapular injuries were seen with the "Direct impact" mechanism. The authors found that glenohumeral dislocations may involve a range of pathologies including Bankart lesions, Reverse Bankart lesions and Superior Labral Anterior-Posterior (SLAP) tears. Interestingly 63% of injuries were to the right shoulder. The shoulder injury occurred in the tackle in 71%, ruck or maul in 12.5%, open play in 12.5% and the scrum in 4% (Table 2).

Malone et al., (2009) examined the pathologies in 183 shoulders of 176 collision athletes who had undergone surgery for a glenohumeral shoulder injury sustained in collision sport.[7] The athletes were predominantly rugby union players from New Zealand and England. The mean age at initial shoulder injury was 21.5 years and 72 were elite (national or provincial) players. Two thirds had sustained a documented glenohumeral dislocation, but one third had sudden injury with collision without known dislocation. Players who sustained injury in a "direct hit" mechanism were more likely to have an associated neurological lesion or posterior labral tear compared to Abduction External Rotation tackling injuries (Table 3).

We have observed a number of recurring injury mechanisms and injuries in rugby players that are directly attributable to some of the unique collisions seen in modern rugby union (Table 4).

Common injury mechanisms

"Bottomed out" refers to the player falling on the outstretched arm, with the sensation of the axilla "bottoming out" forcefully against the ground. Other players may load the joint further by falling on the player's shoulder. This is similar to some cases of the "try scorer" mechanism described by Crichton et al.[6] In this mechanism there is a tensile force on the antero-inferior glenohumeral structures, a potential posterior 'peel back' force on the postero-superior labrum and a compression force on the superior rotator cuff beneath the acromion. The shoulder may dislocate or sublux. Injuries on the tensile side include Bankart labral tears, bony Bankart injuries and humeral avulsions of glenohumeral ligaments (HAGL lesions). Injuries on the compression side include Superior Labral Tears Anterior-Posterior (SLAP lesions), rotator cuff contusions and rotator cuff tears Figure 3.

"Stepped" refers to the defensive player tackling with an outstretched arm, off balance, with the ball carrier nearly past the tackler. This may occur when the ball carrier sidesteps the tackler. The tackler's abducted arm is already near maximum extension, and is further forcefully extended. This may cause glenohumeral dislocation or subluxation, with Bankart/labral tears. The eccentric contraction of anterior musculature may also result in pectoralis major or subscapularis tears.

Common mechanisms of shoulder injury reported by Crichton et al. (2012)

Mechanism	Forces	Resultant pathology
"Try scorer"	Hyper-flexion	• GHJ dislocation: ○ Bankart ○ Reverse Bankart ○ SLAP tear • Rotator Cuff tears (83% of rotator cuff tears caused by this mechanism)
"Tackler"	Extension of abducted arm	• GHJ dislocation: ○ Bankart ○ Reverse Bankart ○ SLAP tear
Direct blow	With arm by side/adducted	• GHJ dislocation & labral tears (38%) • AC joint injuries • Scapula fractures

Abbreviations: GHJ, glenohumeral joint; SLAP, superior labrum anterior to posterior; AC, acromioclavicular.
(James Crichton et al., 2012).

Table 2

Shoulder pathologies resulting from an abduction-external rotation or direct hit tackle

Pathology	ABER tackle	Direct hit
Soft tissue Bankart	79%	33%
Posteroinferior labral tear	11%	50% (bone)
Bone Bankart	26%	11%
Hill—Sachs lesion	58%	22%
Rotator cuff tear	32%	12%
Neurological lesion	15%	32%
Frank dislocation	65%	39%

(Malone et al., 2009).

Table 3

Common injury mechanisms and resulting pathology observed by the author

Mechanism	Pathology
"Bottomed out" (hyper-flexion)	Cuff, anterior instability lesions[a]
Stepped	Bankart, pectoralis major, subscapularis
Front-on tackle	Anterior dislocations, labral, tendon injuries
Hit up	Chondral, labral, fractures, anterior or posterior dislocation, scapula neck fracture
Blown out	Dislocation, Bankart
Drilled	AC joint, chondral, labral, clavicle and scapula fractures, SC joint
Fall forward on elbow/arm	Posterior instability lesions[b] or anterior dislocation
Weight training	AC joint osteolysis, pectoralis major

Abbreviations: AC, acromioclavicular; SC, sternoclavicular.
[a] Anterior instability lesions: Bankart, other labral lesions including SLAP, bone Bankart, HAGL, Hill–Sachs.
[b] Posterior instability lesions: Posterior Bankart, labral lesions, posterior bone Bankart, reverse Hill-Sach's.

Table 4

The "front-on tackle" with the arm in abduction and external rotation and the tackler's shoulder contacting the opponent can cause glenohumeral dislocation, subluxation or tendon injuries, but is less likely to do so than the "stepped" mechanism. "Hit up" refers to the collision of opponents with the arm adducted at the side. This is similar to the "direct impact" mechanism described by Crichton et al.[6] This may occur as the ball carrier "hits the ball up" with a direct charge in to opponents or a shoulder charge by a defender. Anterior or posterior labral, chondral or bony injuries may result. The patient may have an anterior or posterior instability episode or AC joint injuries may occur. We also have experience of players who are in good positions going into a tackle but sustain a significant direct blow to the anterior region of the shoulder when trying to make a 'big hit', resulting in a fracture of the neck of scapula.

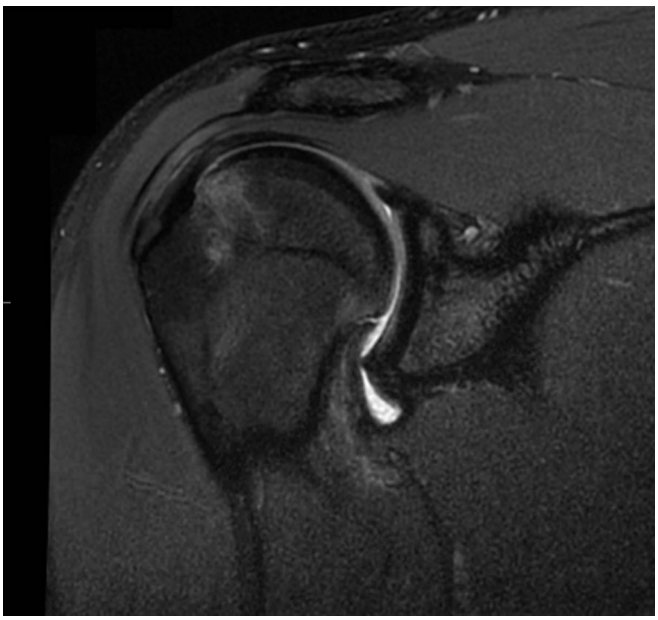

Figure 3 Rotator cuff and greater tuberosity contusion in a professional rugby player after his shoulder "bottomed out". It was slow to settle, with 5 months conservative treatment before return to playing.

"Blown out" refers to the player contesting a ball on the ground at a ruck, bending over with arms outstretched and being "blown out" of the ruck by the charge of an opponent. If the opponent forcefully impacts the player's shoulder in this position, the proximal humerus is forced downwards and antero-inferior dislocation or subluxation may occur.

"Drilled" refers to the player being driven forcefully into the ground onto the tip of the shoulder. This is similar to the "direct impact" mechanism described by Crichton et al.[6] Usually the injured player is the ball carrier. Player's may sustain AC joint injuries, labral injuries, chondral injuries, fractures of the clavicle or scapula or sternoclavicular joint injuries.

"Fall forward on elbow/arm" refers to the player falling forward at speed onto the arm of flexed elbow. Usually the player would be the ball carrier, but this may occur to the tackler or during any fall. When the player falls on the elbow in front of them, the shoulder is often in a position of internal rotation and the posterior translation force may result in posterior instability lesions including reverse Bankart lesions and reverse HAGL lesions. With the shoulder in a more externally rotated position, anterior glenohumeral instability may occur.

There is now a significant focus on gym-based strength training to develop the strength and power needed to play the modern game at a high level. This has resulted in an increased incidence of weight-training related injuries. "Weight training" injuries we have seen include sudden tissue failure against heavy load, specifically pectoralis major rupture, rotator cuff tears and glenohumeral instability with bench press, and more gradual onset of shoulder pain with distal clavicle osteolysis. Anecdotally there have been some shoulder instability issues reported related to over-head power-lifting.

Neurological injuries may occur with a variety of mechanisms. "Stingers" describe the sudden transient numbness, paraesthesiae or pain in the arm after trauma. The mechanism may be a traction injury to the brachial plexus with forceful distraction of the head and shoulder or a direct blow over the plexus.[8] We have also seen neurological injuries as a result of a "closing down" mechanism, where the nerve root is compressed as it exits the foramen. Usually symptoms last for seconds to minutes and the player is able to play on. If symptoms are longer lasting, they are unable to play on and require further neurological evaluation. Axillary nerve lesions may occur in association with anterior instability episodes. Usually spontaneous recovery occurs over several months. Other neurological injuries that may occur include long thoracic nerve injuries and suprascapular nerve injuries although these are rare.[8] We had experience with a case of suprascapular nerve damage associated with fractured neck of scapula.

Patient evaluation

When evaluating the injured collision athlete in a clinical situation an initial perspective should be obtained regarding their sport, playing position (particularly in rugby), grade of competition, future sporting goals and season timing. This information

may influence decision making. For example, a final year school student in the top school team may identify that year as their main sporting goal. Some may not be looking to play after leaving school. Such a player would be hoping to be managed to get through the remainder of the season and have surgery, if required, at the end of the season. Others may identify that the next year is more important and to progress they need to resolve their injury problem promptly and have surgery if required. As player safety and the long-term well-being of the patient are paramount, there are some injuries where it is clear that surgery is indicated acutely e.g. pectoralis major rupture.

History

The history of injury is important. When did injury occur? What was the mechanism? Has there been lost game and training time? What have been the treatments to date and what has been the response to treatment? What are the current symptoms? Remember the collision athlete may have pain and weakness with labral and chondral injuries, without instability symptoms.

Physical examination

Clinical examination follows the same systematic process used in all orthopaedic patients. Observe wasting (e.g. deltoid wasting with axillary nerve palsy) and deformity (e.g. AC joint dislocation). Palpate for tenderness, e.g. AC joint tenderness in distal clavicle osteolysis. Evaluate active and passive range of motion and compare to the other shoulder. Muscle strength should be evaluated with manual muscle testing or dynamometry.

Laxity: it is important to look for signs of hyperlaxity when evaluating patients with glenohumeral instability. Balg and Boileau found a number of factors that were associated with higher recurrence rate after glenohumeral stabilizations using the arthroscopic Bankart procedure.[9] These included age <20 years, high risk activities, competitive level of participation, shoulder hyperlaxity, and significant glenoid and humeral bone lesions. All these risk factors are common in the collision athlete. They defined shoulder hyperlaxity as greater than 85° of external rotation of the shoulder with the arm at the side or a positive Gagey sign.[10] A positive Gagey sign is passive glenohumeral abduction 20°greater than the uninjured side. Shoulder hyperlaxity in the patient with glenohumeral instability may influence the surgeon's choice of surgical procedure.

Stewart and Burden examined 51 first division male rugby players for ligamentous laxity using the Beighton-Horan score.[11] Players were grouped as tight (score 0–3), hypermobile (score 4–6) or excessively hypermobile (score 7–9). The incidence and nature of player injuries was prospectively followed through the season. There was no difference in the peak strength measurements in the hypermobile and tight groups. The incidence of injuries was significantly higher in the hypermobile groups, with the incidence of injury/1000 exposure hours being 43.6 in the tight group and nearly 3 times greater at 116.7 in the hypermobile groups ($p = 0.034$). The shoulder, knee, ankle and wrist/hand had fairly similar injury rates (13.7, 15.7. 17.6, 11.8 per 100 exposure hours respectively).

Orthopaedic tests: special tests should be used to evaluate for specific diagnoses including apprehension and relocation tests for instability, cuff strength and impingement tests for cuff pathology, AC joint tenderness and provocation tests for AC joint pain and labral tests. However, the sensitivity, specificity and reliability of special tests in the evaluation of the shoulder, especially labral tests, are variable.[12]

Imaging

Imaging includes plain radiographs to evaluate the AC joint and to check for fractures and bone injuries that may occur in traumatic instability, including bony Bankart injuries and Hill–Sachs lesions. Although more expensive, MRI arthrography is a far more useful imaging modality in these athletes than ultrasound scans. MRI arthrograms are useful in the diagnosis of labral tears and rotator cuff injuries. If there are concerns regarding bony Bankart or other fractures, CT scans, including 3D reconstructions, are useful.

Treatment options and rehabilitation for specific injuries

Non-surgical conditions

There are a number of diagnoses for which we usually utilise initial non-operative treatments. These include Grade 1–3 AC joint injury, distal clavicle osteolysis, most clavicle fractures (unless widely displaced, shortened or threatening the skin or neurovascular structures), non-displaced glenoid fractures, low grade partial thickness rotator cuff tears (Figure 4) and labral tears without symptoms of glenohumeral instability.

Conservative management programmes: non-operative treatments include initial activity modification, physiotherapy, graduated loading and return to sport progression. The player may often still perform aerobic, core and lower limb conditioning and strengthening exercises. Physiotherapy modalities include the use of cryotherapy, range of motion and graduated strengthening, emphasizing scapula and dynamic rotator cuff control, with clinical and functional goal-oriented progression through to skill work, non-contact training, light contact then full contact training. Typically, players would have completed 2 weeks of full contact training before playing. Taking time to address any technique-related issues during the return to play program will be worthwhile in reducing recurrence. Utilizing a coach can be very helpful e.g. in correcting tackle technique issues. Usually the return to game time is graduated, with progressively increasing periods of playing time. Cortisone injections may be used in certain situations e.g. AC joint pathology and traumatic subacromial bursitis that may result from the "try scorer" mechanism of injury, and for rotator cuff contusion without significant rotator cuff tear that may result from the "bottomed out" mechanism of injury.

Acromioclavicular joint pain (without instability): AC joint pain, without AC instability, may occur acutely after direct impact (Rockwood Grade 1 injury) or gradually with heavy lifting and weight training (distal clavicle osteolysis). Once the AC joint is symptomatic it may continue to be aggravated by impact or heavy lifting. If symptoms cannot be adequately controlled and resolved by a period of activity modification and AC joint cortisone injection, we may recommend surgery. Our usual approach in the treatment of isolated AC joint pain without

Figure 4 Symmetrical contour of the pectoralis major muscles in a professional rugby player after repair of right pectoralis major tendon avulsion.

instability is a mini-open excision of the outer end of clavicle (3 mm) and excision of the intra-articular disc. Although the surgeon author commonly utilizes an arthroscopic approach in the general population, we believe the mini-open approach is preferable in the collision athlete, to allow imbrication of the AC joint ligaments and delto-trapezial fascia, providing further stability for collisions and impact. Patients wear a sling for 2–3 weeks after surgery then rehabilitate with range of motion and strengthening exercises. We have tended to perform this surgery in the short "off season" period in professional rugby players with the players returning to professional and international rugby 2–3 months from surgery. In our experience, surgical treatment of AC instability in the elite collision athlete is uncommon.

Surgical management

There are some diagnoses where we usually advise acute surgical management. These include pectoralis major tendon ruptures, full thickness rotator cuff tears and some cases of anterior glenohumeral dislocation. In cases of dislocation, there are injury and patient factors that influence treatment and timing of treatment. These are considered later in this paper.

Pectoralis major rupture: pectoralis major ruptures may occur as a result of eccentric loading. We have seen this injury in professional rugby players with different mechanisms, including tackling, scrum collapse and weight training (bench press). Patients experience the sudden onset of pain and contour change in the pectoralis major and anterior axillary fold. The diagnosis of pectoralis major avulsion can be confirmed with MRI scans. We favour prompt surgical treatment, reattaching the avulsed tendon to the humerus with suture anchors. We prefer unicortical, small, offset drill holes for these anchors to minimize stress risers in the humerus in these collision athletes. With anatomical repair and good healing, the normal contour, strength and function of the pectoralis major is restored (Figure 4). Patients wear a sling for 6 weeks, with some gentle passive movements in that period, then active range of movement, followed by progressive strengthening and a gradual return to sport. A well-structured 'return to play' plan is important to achieving a successful outcome. The professional rugby players we have treated with this injury have returned to professional rugby and, in some cases, progressed through to international level.

Anterior glenohumeral instability: treating the collision athlete with shoulder instability is demanding and humbling. These athlete's shoulders are submitted to extreme forces and the hard end point of recurrent instability is a clear negative outcome. Many players experience traumatic instability of their other shoulder and this reflects the demands on the collision athlete's shoulders.

Surgical procedures include arthroscopic or open Bankart and bony Bankart repairs, Bristow–Laterjet Bone block procedures and other bone augmentation techniques. Each may be performed with some amount of capsular shift. Currently there appears to be a consensus view that patients with significant bone defects, more than 15–20% of the glenoid, should be managed with a bone restoring or augmenting procedure (Figure 5). This may be repair of a Bony Bankart lesion, where possible. If there is bone loss or an inadequate bone fragment, bone restoration and augmentation techniques include Bristow–Laterjet coracoid transfer or iliac crest bone graft. These procedures enhance stability by restoring the area of the glenoid. The Bristow–Laterjet procedures have the advantage of providing additional stability through the sling effect of the conjoined tendon. A case can be made for routinely performing Bristow–Laterjet procedures in

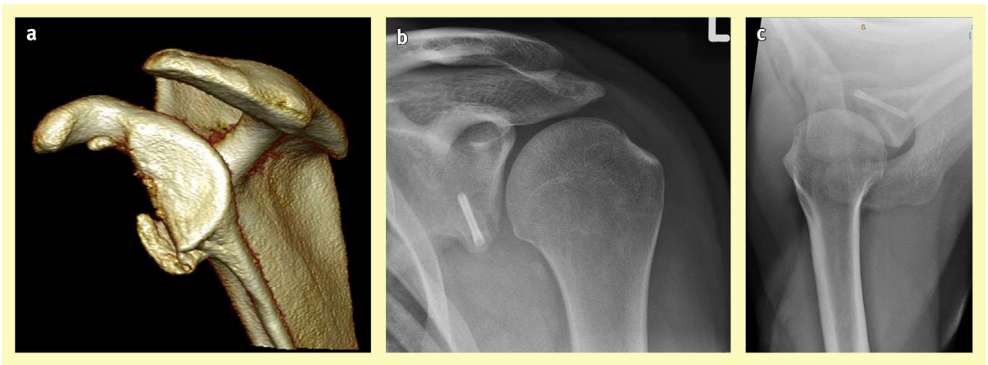

Figure 5 (**a**) CT image of a chronic bone Bankart lesion in a high school rugby player. This patient could not raise his arm overhead without the shoulder subluxing. (**b**) AP X-ray and (**c**) axial X-ray of the same player following Bristow–Laterjet procedure.

these high risk athletes, as the recurrence rate of dislocation is generally considered to be lower with this procedure compared to arthroscopic Bankart repair. However the arguments against performing primary Bristow–Laterjet procedures in the absence of significant bone loss include the loss of this procedure as a revision option in cases of recurrence and the significant complication rate of Bristow–Laterjet procedures. The reported complications include neurological injuries, hardware problems, non-union[13,14] and arthrosis.[15]

Some author's believe that the results of arthroscopic Bankart repairs are as good as open Bankart repairs[16] in the collision athlete, and in some centres, open Bankart repairs are now uncommon. Mazocca et al. reviewed the results of arthroscopic anterior stabilization in 13 collision athletes with average follow up of 37 months (range 24–66 months).[17] There were 2 recurrent dislocations (15%). They felt these results supported the use of the technique, concluding that participation in collision sports was not a contraindication to arthroscopic stabilization.

We are unaware of any large prospective randomized trials comparing open versus arthroscopic Bankart repairs in collision athletes. However, Rhee et al. reviewed 48 shoulders in 46 collision athletes in a cohort study in which 16 underwent arthroscopic stabilization and 32 had open repairs.[18] The mean follow up period was 72 months (range 30–136 months). Recurrent dislocations or subluxations occurred in 25% of the arthroscopic group and 12.5 % of the open group ($p = 0.041$). The authors concluded that open surgery was more reliable than arthroscopic surgery for recurrent anterior instability in the collision athlete.

As in all cases of glenohumeral instability, the treating surgeon must consider their own skill set and results when considering surgical techniques, as well as the experience of other experts. The surgical author performs arthroscopic stabilizations and open Bristow–Laterjet procedures, but there is also an indication for open Bankart repairs and capsular shift in our practice with collision athletes, particularly in cases of poor labral quality or capsular laxity. In selected patients, we perform the open Bankart repair with suture anchors with extra-capsular sutures, a capsular shift resulting in a region of double thickness of anterior overlapping capsule. We prefer a laterally-based capsulotomy, as there is some evidence that this is biomechanically superior to glenoid based shift.[19,20] A 42% volume reduction occurs to the joint with a humeral based capsular release to the 6 o'clock position and capsular shift.[21]

Table 5 summarises the surgical author's current preferences for surgical treatments of anterior instability in collision athletes.

The surgical author's preferences for surgical approach in anterior shoulder instability in the collision athlete

Approach	Factors that may influence procedure selection
Arthroscopic stabilisation	• No ligamentous laxity • No significant glenoid bone loss • Significant labral tear with good quality labral tissue • Large Hill–Sachs lesion without significant glenoid bone defect – consider Remplissage • Circumferential labral tears- these patients may have symptoms of pain and weakness more than instability
Open Bankart with capsular shift	• Hyperlaxity • Poor quality labral tissue • Large Bone Bankart fracture • HAGL injuries – HAGL repair
Bristow–Laterjet	• >15–20% glenoid bone loss • Combined significant bone loss, considering Hill–Sachs and glenoid lesions • Revision procedures

Abbreviations: HAGL, humeral avulsion of glenohumeral ligaments.

Table 5

The first-time dislocator

Chahal et al. performed a systematic literature review to compare Bankart repair surgery with non-operative treatment and/or arthroscopic lavage for treatment of first-time traumatic shoulder dislocation.[22] They found four trials with a total of 228 patients. The risk of recurrent instability was 5 times less in the surgical Bankart repair group, than the conservative or lavage groups. The disease specific quality of life scores were also better in the Bankart repair group.

Grumet et al. conducted a systematic review of the literature comparing results of arthroscopic stabilization procedures performed for first time dislocation patients, with those of recurrent instability patients.[23] The authors concluded there were no differences in the recurrence or complication rates among patients undergoing surgery after the initial dislocation compared to those undergoing surgery after recurrent instability.

Patients who sustain a traumatic anterior dislocation are highly likely to have recurrent instability with return to collision sport. We recommend acute stabilisation surgery in those wishing to continue with the sport and career progression in the sport. If however, the player wishes to play within the next several months as a priority e.g. first team in final year of school, it is reasonable to trial conservative treatment. If imaging demonstrates a full thickness rotator cuff tear, HAGL lesion (Figure 6), or displaced bony Bankart fracture, we favour immediate surgery.

Labral lesions and posterior instability

Circumferential pathology, SLAP lesions and some cases of posterior instability are best addressed with an arthroscopic approach (Figure 7). Patients with circumferential labral tears may present with pain and weakness rather than symptoms of instability. SLAP lesions are an uncommon isolated diagnosis in collision athletes and are more often associated with other instability lesions. If they are diagnosed as an isolated finding on an MRI arthrogram, we favour an initial trial of non-operative treatment. SLAP lesions are difficult to reliably diagnose clinically,[12] radiologically[24] and arthroscopically.[25] However Type III SLAP lesions with a bucket handle flap (Figure 8) or SLAP lesions with paralabral cysts causing suprascapular nerve compression are indications for surgery.

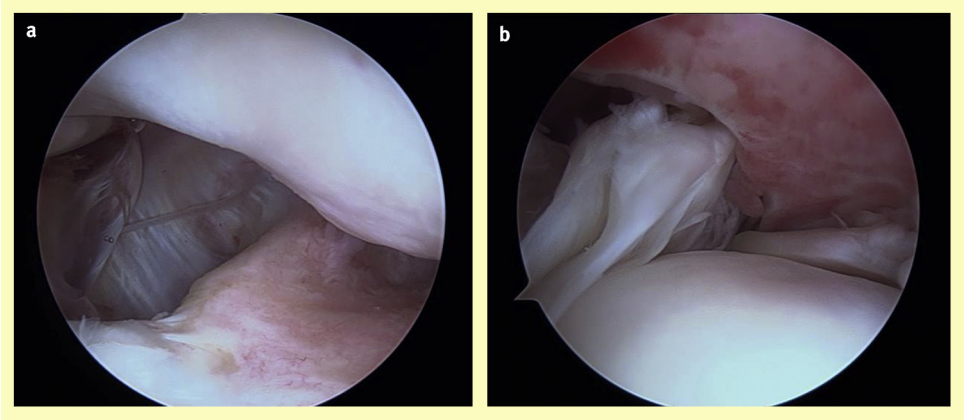

Figure 6 This player sustained a HAGL injury (**a**) and a supraspinatus tear (**b**) when his shoulder "bottomed out" and subluxed while being tackled at the World Junior international rugby tournament. He had surgical repair and has progressed through to senior professional level.

Return to sport time frames and expectations

We favour goal-oriented rehabilitation with progression determined by clinical and functional progress. Initial immobilization following shoulder injury or surgery generally involves sling use, pendulum exercises and light movement exercises for the elbow, wrist and hand. After weaning off the sling the patient and therapist work to regain active-assisted and active range of shoulder movement, scapular control and optimum posture.

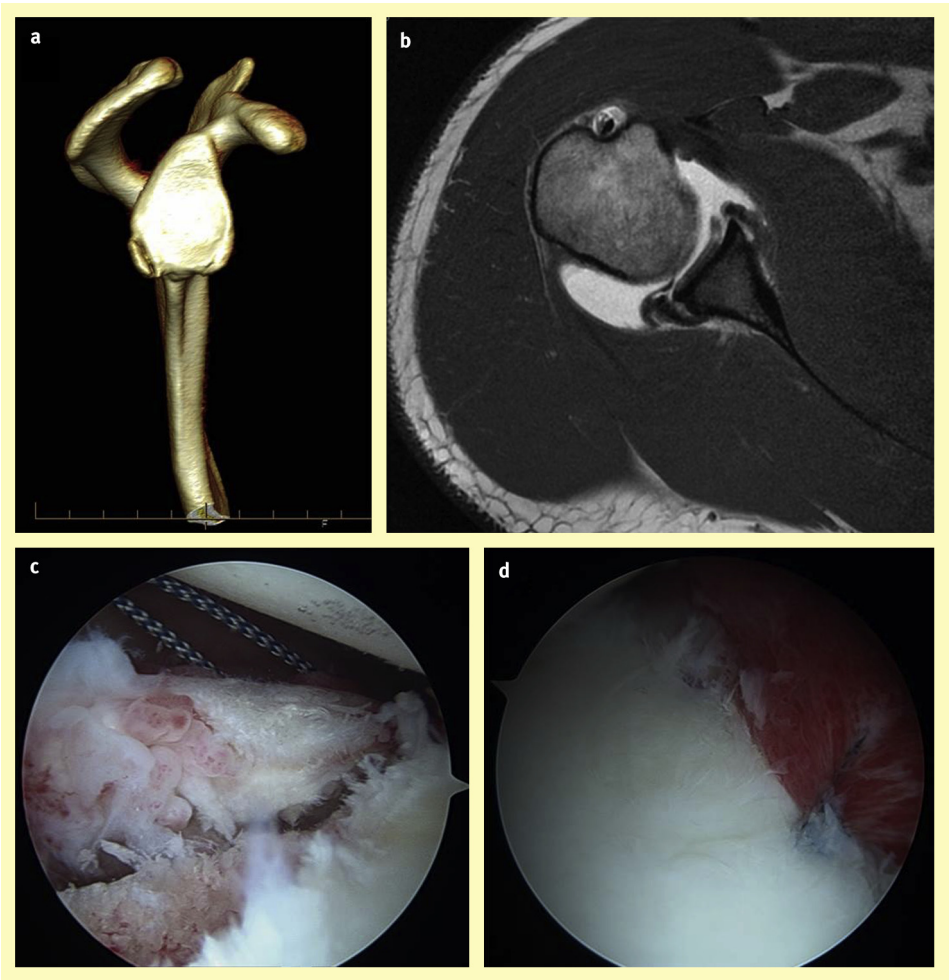

Figure 7 CT reconstruction of the glenoid (**a**) and MRI arthrogram (**b**) in a rugby player presenting with an acute posterior dislocation after a front on tackle mechanism of injury. Imaging demonstrated a posterior Bone Bankart lesion, anterior labral tear and what appears to be a healed anterior bone Bankart lesion, although he did not recall any significant previous shoulder symptoms. Arthroscopic stabilization included mobilization and repair of the anterior Bankart lesion (**c**) and repair of the posterior bone Bankart injury (**d**).

Figure 8 Type III SLAP lesion in an age group rugby player who injured his shoulder in a ruck. He had mechanical symptoms which resolved after arthroscopic resection of the bucket handle flap. He progressed through to senior international level.

Once 80% range of motion with good quality movement has been regained, light inner range theraband strengthening is used. Throughout this process good scapula stability is developed and progressed. This usually takes the patient through to around 12 weeks from surgery. Supervised gym based strengthening is then used as well as proprioceptive retraining and ballistic movements. Once strength is adequate, the patient can participate in non-contact skills work, then light contact and bag work with a focus on developing good technique, followed by 2 weeks of full contact training before returning to limited game time. It is common for players to utilize strapping or bracing during the return to play phase, although research evidence for its efficacy is limited. Table 6 provides some guidelines for time frames for return to playing after common surgical procedures. These are conservative guidelines for patients making good progress with their rehabilitation.

Guidelines for post-operative return to sport timeframes

Procedure	Estimated return-to-sport time
Glenohumeral stabilization	6 months
Labral repair without marked instability	5 months
Pectoralis major rupture	5 months
Rotator cuff repair	6 months
AC osteolysis, excision outer end of clavicle	2–3 months
AC joint stabilization	6 months

Abbreviations: AC, acromioclavicular.

Table 6

We have found that the elite senior and late teenage rugby player nearly always returns to rugby after shoulder injury with the expectation of returning to the same level and progressing in their rugby career. We don't have data regarding children and adolescents return to collision sport following collision shoulder injuries. Younger players, players in lower grades and players nearing retirement sometimes choose to minimize future risk by stopping playing collision sports, especially after recurrent injuries.

Preventative strategies

The unpredictable nature of collision sport makes prevention of shoulder injuries challenging. However the shoulder has been identified as a priority area for injury prevention in rugby union, with shoulder injuries featuring in the top three injuries for both backs and forwards.[26]

Technique modification

The introduction of prevention programmes that educate coaches and referees, such as New Zealand's 'RugbySmart' programme, addressing technique factors associated with injury, have been shown to reduce the incidence of rugby injuries.[27] The decrease in injuries was supported by the results of player surveys indicating a change in behaviour in contact situations including tackles, scrums and rucks.[28] Such programmes appear to be an effective method of reducing injuries over time. Ongoing attention to modifiable technique factors that may contribute to shoulder injury in rugby, particularly in tackle situations may assist in reducing these injuries over time.

Position-specific conditioning

Factors identified as potential risk factors for rotator cuff injury in front-row forwards include rotator cuff weakness, fatigue-induced proprioception and skill deficits and suboptimal glenohumeral alignment.[26] Centres may also be at higher risk of injury due to the higher number of tackles made by centres compared with other backs.[26] This highlights the need for position-specific strength and conditioning programmes to assist with shoulder injury prevention. All players are now expected to be proficient at "cleaning-out" at the break-down and this technique needs to be well coached to be effective and to minimise injury risk.

Fatigue has been associated with reduced performance in repeated tackling situations.[29] Shoulder impact force was shown to reduce with repeated tackling from 1743N (first tackle) to 1571N by the fifth tackle suggesting fatigue may play a factor in shoulder injury highlighting the importance of general conditioning and recovery in injury prevention. General fitness and training to enhance recovery and 'fatigue resistance' may also help minimise injury risk by reducing performance decrements associated with muscle fatigue.

Screening for hyperlaxity

Previous research has identified an increased injury rate in athletes with documented hyperlaxity.[11] Identification of those with hyperlaxity of the shoulder followed by targeted scapulothoracic and glenohumeral motor control and strengthening programmes could theoretically reduce the incidence of lower impact injuries such as ABER tackles.

Protective equipment

The wearing of shoulder pads has been suggested as a possible explanation for the reduced rates of shoulder injury between American football and rugby union in New Zealand, in which the rate of shoulder injury was two thirds higher compared with their American counterparts.[30] However, differences in the demands and forces on the upper limb in both sports preclude definitive conclusions. Shoulder pads in rugby union have been shown to result in only a small reduction in shoulder impact force from 1684N to 1635N using IRB approved pads, reducing peak impact forces by 3%.[29] Such small reductions in impact forces are unlikely to prevent high-impact injuries such as fractures and dislocations that, by nature, also involve bending and torsional forces that shoulder pads are not designed to resist. Shoulder instability braces are often worn in rugby union, however there is no clear evidence of benefit for these braces in preventing episodes of shoulder instability.

Long-term outlook

There are no data quantifying the risk of longer term deterioration in the collision athlete's shoulder. Hovelius et al. conducted a large, multi-centre study in Sweden in which 255 patients aged between 12 and 40 years with primary anterior dislocations were followed for 25 years.[31] Although not all patients suffered a dislocation as a result of a collision injury this is one of the few long-term studies involving athletic populations. Radiological imaging was obtained in 97% of the original cohort at 25-year follow-up with arthropathy reported as mild in 29%, moderate in 9% and severe in 17%.

The age of the patient at the time of the injury, age at time of surgery, primary dislocation caused by high energy sports activity, the number of dislocations and the time elapsed between injury and operative intervention have been identified as risk factors for arthritic changes after dislocation.[31,32] Mild arthropathy at 10-year follow-up increased the risk of developing severe arthropathy, with 63% of those with mild arthropathy at 10 years showing severe arthropathy at 25-years, compared with only 9% of those who had no joint changes at 10-year follow-up ($P < 0.001$).[31] Joint incongruence at 10 years was also strongly associated with moderate/severe arthropathy at 25 years ($P < 0.001$).[31] The development, and subsequent severity of the arthritic changes however, do not appear to be related to the method of management of instability (conservative vs surgical).[33]

The New Zealand Joint Replacement Registry 15-year Report shows that, of the 5528 primary shoulder arthroplasty procedures performed, 106 (1.9%) reported having previous stabilisation surgery.[34] Buscayret et al. reported the prevalence of post-operative arthritis to be 19.7% among patients who had previous stabilisation surgery.[32] However, this figure also includes lesser grades of arthritis severity and they do not report the proportion of patients who proceeded to arthroplasty surgery.

Conclusions

- Shoulder injuries in collision sports are common.
- There is a wide range of injury mechanisms, injuries and treatments.
- The short- and long-term effects of injury, season and career timing may influence decision making.
- Player welfare is paramount.
- Collision athletes train to gain strength and mass, and injuries may be sustained due to weight training.
- The expectation of treatment in competitive athletes is usually to return to sport at the same level or continue playing career progression.
- Well planned rehabilitation and a structured return to play program is required to minimise the risk of injury recurrence.
- Preventative strategies are not well defined.
- The long-term effects of collision shoulder injuries have not been well defined and no clear risk factors have been identified for the development of arthritic changes. ◆

REFERENCES

1 Brooks J, Fuller C, Kemp S, Reddin D. Epidemiology of injuries in English professional rugby union: part 2 training Injuries. *Br J Sports Med* 2005; **39:** 767–75.

2 Fuller CW, Laborde F, Leather RJ, Molloy MG. International Rugby Board Rugby world Cup 2007 injury surveillance study. *Br J Sports Med* 2008; **42:** 452–9.

3 England Professional Rugby Injury Surveillance Project Steering Group. England professional rugby injury surveillance project. Twickenham: England Rugby Union, 2013.

4 King D, Hume P, Gianotti S, Clark G. A retrospective review over 1999 to 2007 of head, shoulder and knee soft tissue and fracture- dislocation injuries and associated costs for rugby league in New Zealand. *Int J Sports Med* 2011; **32:** 287–91.

5 Usman J, McIntosh AS. Upper limb injury in rugby union football: results of a cohort study. *Br J Sports Med* 2013; **47:** 374–9.

6 Crichton J, Jones DR, Funk L. Mechanisms of traumatic shoulder injury in elite rugby players. *Br J Sports Med* 2012; **46:** 538–42.

7 Malone AA, Funk L, Mohammed K, Ball CM. Shoulder instability in the collision athlete – the "collision shoulder". Paper presented at: British Elbow and Shoulder Society Conference 2009. London.

8 Busconi B, Baker C, Gill T. Shoulder injuries in football. In: Wilk K, Reinold A, Andrews J, eds. The Athlete's shoulder. Philadelphia: Churchill Livingstone, Elsevier, 2009; 421–9.

9 Balg F, Boileau P. The instability severity index score: a simple pre-operative score to select patients for arthroscopic or open shoulder stabilisation. *J Bone Joint Surg Br* 2007; **89:** 1470–7.

10 Gagey OJ, Gagey N. The hyperabduction test. *J Bone Joint Surg Br* 2001; **83:** 69–74.

11 Stewart DR. Does generalised ligamentous laxity increase seasonal incidence of injuries in male first division club rugby players? *Br J Sports Med* 2004; **38:** 457–60.

12 Hegedus EJ, Goode AP, Cook CE, et al. Which physical examination tests provide clinicians with the most value when examining the shoulder? Update of a systematic review with meta-analysis of individual tests. *Br J Sports Med* 2012; **46:** 964–78.

13 Griesser MJ, Harris JD, McCoy BW, et al. Complications and re-operations after Bristow-Latarjet shoulder stabilization: a systematic review. *J Shoulder Elbow Surg* 2013; **22:** 286–92.

14 Shah AA, Butler RB, Romanowski J, Goel D, Karadagli D, Warner JJP. Short-term complications of the Latarjet procedure. *J Bone Joint Surg Am* 2012; **94:** 495–501.

15 Mizuno N, Denard PJ, Raiss P, Melis B, Walch G. Long-term results of the Latarjet procedure for anterior instability of the shoulder. *J Shoulder Elbow Surg* 2014; **23:** 1691—9.

16 Harris JD, Romeo AA. Arthroscopic management of the contact athlete with instability. *Clin Sports Med* 2013; **32:** 709—30.

17 Mazzocca AD, Brown FM, Carreira DS, Hayden J, Romeo AA. Arthroscopic anterior shoulder stabilization of collision and contact athletes. *Am J Sports Med* 2005; **33:** 52—60.

18 Rhee YG, Ha JH, Cho NS. Anterior shoulder stabilization in collision athletes: arthroscopic versus open Bankart repair. *Am J Sports Med* 2006; **34:** 979—85.

19 Wang VM, Sugalski MT, Levine WN, Pawluk RJ, Mow VC, Bigliani LU. Comparison of glenohumeral mechanics following a capsular shift and anterior tightening. *J Bone Joint Surg Am* 2005; **87:** 1312—22.

20 Deutsch A, Barber JE, Davy DT, Victoroff BN. Anterior-inferior capsular shift of the shoulder: a biomechanical comparison of glenoid-based versus humeral-based shift strategies. *J Shoulder Elbow Surg* 2001; **10:** 340—52.

21 Wiater JM, Vibert BT. Glenohumeral joint volume reduction with progressive release and shifting of the inferior shoulder capsule. *J Shoulder Elbow Surg* 2007; **16:** 810—4.

22 Chahal J, Marks PH, Macdonald PB, et al. Anatomic Bankart repair compared with non-operative treatment and/or arthroscopic lavage for first-time traumatic shoulder dislocation. *Arthroscopy* 2012; **28:** 565—75.

23 Grumet RC, Bach BRJ, Provencher MT. Arthroscopic stabilization for first-time versus recurrent shoulder instability. *Arthroscopy* 2010; **26:** 239—48.

24 Jee WH, McCauley TR, Katz LD, Matheny JM, Ruwe PA, Daigneault JP. Superior labral anterior posterior (SLAP) lesions of the glenoid labrum: reliability and accuracy of MR arthrography for diagnosis. *Radiology* 2001; **218:** 127—32.

25 Gobezie R, Millett PJ, Cole BJ, Warner JJ. Analysis of interobserver and intraobserver variability in the diagnosis and treatment of SLAP tears using the Snyder classification. *Am J Sports Med* 2008; **36:** 1373—9.

26 Brooks J, Kemp S. Injury prevention priorities according to playing position in professional rugby union players. *Br J Sports Med* 2011; **45:** 765—75.

27 MacQueen AE, Dexter W. Injury trends and prevention in rugby union football. *Curr Sports Med Rep* 2010; **9:** 139—43.

28 Gianotti SM, Quarrie KL, Hume PA. Evaluation of RugbySmart: a rugby union community injury prevention programme. *J Sci Med Sport* 2009; **12:** 371—5.

29 Usman J, McIntosh AS, Fréchède B. An analysis of impact forces in an active shoulder tackle in rugby. *Br J Sports Med* 2011; **45:** 328—9.

30 Marshall SW, Waller AE, Dick RW, Pugh CB, Loomis DP, Chalmers D. An ecologic study of protective equipment and injury in two contact sports. *Int J Epidemiol* 2002; **31:** 587—92.

31 Hovelius L, Saeboe M. Arthropathy after primary anterior shoulder dislocation -223 shoulders prospectively followed up for twenty-five years. *J Shoulder Elbow Surg* 2009; **18:** 339—47.

32 Buscayret F, Edwards TB, Szabo I, Adeleine P, Coudane H, Walch G. Glenohumeral arthrosis in anterior instability before and after surgical treatment. *Am J Sports Med* 2004; **32:** 1165—72.

33 Matsoukis J, Tabib W, Guiffault P, et al. Shoulder arthroplasty in patients with prior anterior shoulder dislocation. *J Bone Joint Surg Am* 2003; **85:** 1417—24.

34 NZ Orthopaedic Assocation. New Zealand joint registry 14 year report. Christchurch: New Zealand Orthopaedic Association, November 2014.