



# Minimizing Risk of Recurrent Instability Following Surgical Stabilization for Anterior Glenohumeral Instability

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## KEYWORDS

• Shoulder instability • Remplissage • Latarjet • Return to sport • Glenoid track

## KEY POINTS

- The risks of delayed versus immediate surgical stabilization for an in-season athlete following a first-time shoulder dislocation warrants an individual discussion with each patient.
- Management of glenoid bone loss values between 10% and 20% may benefit from additional procedures, including Bankart repair with remplissage.
- Surgeons should consider patient-specific risk factors, extent of pathology, indications of available treatment options, and individual patient activity goals to maximize clinical outcomes and minimize recurrent instability rates.

## BACKGROUND

### Epidemiology and Trends

Anterior glenohumeral instability is a common orthopedic condition in young, active patients and presents a clinical challenge for orthopedic surgeons.<sup>1–3</sup> While the incidence rate in the general population is about 0.08 per 1000 person-years, the incidence rate increases dramatically in young athletes (0.51 per 1000 athlete exposures) and military personnel (1.69 per 1000-person years).<sup>4</sup> Without surgical fixation, those with anterior shoulder instability can experience reoccurrence rates as high as 90% in the young athletic population, with hyperlaxity and bone loss further increasing the recurrence risk.<sup>4</sup> While nonoperative management is an option in select patient populations, surgical options are typically favored to both prevent further injury to the glenohumeral joint in addition to reducing

recurrent rates.<sup>1–3</sup> The purpose of this article is to discuss the timing of surgery in the in-season athlete, evaluate the evolving concept of glenoid and bipolar bone loss, and to discuss various surgical treatment options with a specific focus on minimizing recurrent instability rates following surgical stabilization.

Surgical management of anterior glenohumeral instability has evolved significantly over recent decades, beginning with open stabilization techniques, including open labral repair and capsular shift, the Latarjet procedure (open coracoid transfer), and the Bristow-Helfet procedure (coracoid tip transfer), all of which can be reliable and beneficial open surgical options.<sup>5</sup> After 1980, however, with the introduction of arthroscopic labral repair techniques, open procedures lost popularity as trends shifted toward achieving similar outcomes with minimally invasive procedures.<sup>5–7</sup>

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To date, the most common treatment options for anterior shoulder instability include the arthroscopic Bankart repair (ABR) with or without adjunct procedures such as remplissage, the open Bankart repair, the Bristow-Latarjet procedure, and anterior free bone block transfers utilizing autograft or allograft.<sup>7</sup> Interestingly, the debate surrounding the optimal treatment technique is heavily dependent upon geographic location. In the United States, for example, the ABR has consistently maintained popularity, accounting for approximately 90% of shoulder stabilization procedures, and provides the advantages of being a minimally invasive procedure with low complication rates, and historically low recurrence rates.<sup>6–8</sup> Further, in the United States, Latarjet is typically utilized in most commonly in the setting of significant glenoid bone loss either in primary or revision scenarios.<sup>9</sup> In Europe, however, Latarjet in the primary setting is much more common, even cases of less than 15% glenoid bone loss.<sup>9</sup> The Latarjet procedure utilization increased by more than 250% in the past decade in the United States, and recent systematic reviews have shown that the Latarjet, when used as a primary stabilization procedure, demonstrates good functional outcomes, low revision rates, and high return to play rates.<sup>7,10</sup> Further, Rodkey *and colleagues* found outcomes following primary Latarjet to be comparable to those in the revision setting following a failed ABR in a retrospective, comparative cohort study of 234 patients.<sup>11</sup> The decision between arthroscopic and open techniques in the management of anterior glenohumeral instability remains subject to debate. ABR presents a less invasive procedure, avoids alteration of glenohumeral joint anatomy, has shown a lower complication profile, and can provide better preservation of range of motion, while the Latarjet demonstrates lower recurrence rates in most studies, which must be balanced against a higher complication profile.<sup>5,12–14</sup> Supplementation of ABR with remplissage has been shown to have excellent outcomes, and its use is becoming increasingly prevalent in patients with subcritical bone loss and additional risk factors for recurrent instability.<sup>15–17</sup> Additionally, recent literature has shown that ABR with remplissage has higher rates of return to sport when compared to ABR or Latarjet in addition to comparable rates of recurrence.<sup>18</sup>

The management of anterior glenohumeral instability in high-risk populations, including young (<20 yr old) contact athletes, has continued to evolve. This article will outline techniques to minimize the risk of recurrent instability following

surgical stabilization for anterior shoulder instability, focusing on 3 major considerations: the management of the in-season athlete with anterior glenohumeral instability, critical glenoid bone loss and additional risk factors for recurrence, and the indications and outcomes of various surgical treatment options.

## MANAGEMENT OF THE IN-SEASON ATHLETE

The athlete experiencing an in-season instability event presents a complex clinical challenge for the orthopedic surgeon and an involved discussion with the athlete regarding the risks and benefits of operative and nonoperative management. While nonoperative management can allow a high rate for players to return to play in the same season, this decision must be weighed against the consequences of sustaining an additional instability event in the same season, including further glenohumeral cartilage damage, increasing bipolar bone loss, and potentially worse clinical outcomes following eventual surgical stabilization.

The primary concern with continued in-season play with delayed surgical intervention is instability recurrence. The biomechanical impact of recurrent dislocations has been shown to negatively impact the stability and capsular integrity of the joint. Yoshida *and colleagues* showed that glenohumeral joint kinematics were altered after a single dislocation and worsened with subsequent dislocations.<sup>19</sup> Further, they showed that the force required to dislocate lowered after just the primary dislocation and further after multiple dislocations.<sup>19</sup> This was paired with an observed increase in anterior translation after the primary dislocation and again after a 3rd dislocation.<sup>19</sup> Clinically, this has been seen, as Yiannakopoulos *and colleagues* found that chronic recurrent instability patients had significantly greater labral tear extension, with higher rates of Hill-Sachs lesions, inverted pear glenoids, and capsular laxity.<sup>20</sup> These injuries translate to higher odds of failure after ABR, as Vaswani *and colleagues* found an increased odds ratio (OR) of failure in those undergoing ABR following multiple dislocations, noting an increase from an OR of 2.4 for 2 dislocations to 8.1 for those with 6 or more preoperative instability events.<sup>21</sup> This literature suggests that athletes choosing to return to play in the same season are at risk for higher rates of failure following surgical stabilization, increased capsulo-labral and glenoid damage, and worse postoperative outcomes should they sustain an additional instability event prior to surgical stabilization.

Literature has shown that in-season athletes choosing to avoid surgical intervention following anterior instability events can return to sport at high rates, as one study reported that 87% of in-season athletes returned to sport in the same season, with an average time missed of only 10 d. Further, additional literature has shown that 85% of non-operatively managed athletes were able to complete the subsequent season.<sup>22,23</sup> Shanley *and colleagues* found a 3-fold higher return to sport rate for those following subluxations when compared to dislocations; however, the authors defined success as completion of the subsequent season, and patients who had recurrence without time loss were considered a success.<sup>23</sup> Further, Buss *and colleagues* and Dickens *and colleagues* found recurrent instability rates of 37% and 64%, respectively, among athletes returning to play in the same season, with only 27% of athletes completing the season without another instability event.<sup>22,24</sup> The current literature suggests that while in-season athletes return to sport at high rates following nonoperative management, this comes with an elevated risk of subsequent instability events, which have further downstream consequences.

Operative stabilization in the off-season can result in excellent rates of return to play, with 1 investigation of division I collegiate football players reporting that those athletes undergoing operative stabilization were 5.8 times more likely to complete the subsequent season compared to those undergoing nonoperative management (90% vs 40% return to play). However, despite the success of late operative management for return to play, it is important to note that recurrent instability is an entirely different outcome. When counseling the in-season athlete regarding nonoperative management, one must consider the clinical and biomechanical risks of sustaining recurrent instability events.

There is extensive evidence that surgical stabilization following first-time instability events reduces recurrence rates and improves patient reported outcomes.<sup>25–27</sup> Yapp *and colleagues* recently published 10-year follow-up from a randomized control trial that compared outcomes following ABR and arthroscopic irrigation and debridement, finding 35% lower rates of redislocation and lower rates of recurrent instability on survival curve analysis for ABR, with better Western Ontario shoulder instability index (WOSI) scores.<sup>25</sup> Notably, most recurrences in this population occurred within the first 2 y post-operatively, and those with recurrent instability experienced worse patient reported outcomes.<sup>25</sup>

Earlier research on the same cohort demonstrated that the risk of discontinuing contact sports within the first 2 y after primary dislocation was higher (RR 3.4) for the lavage group compared to the ABR group.<sup>27</sup> Further, these findings have been similarly reported at 2 y follow-up by Pougès *and colleagues* in another randomized control trial comparing ABR to non-operative treatment with immobilization followed by the same physical therapy protocol for both groups.<sup>28</sup> The authors found a 60% difference in recurrent instability for surgically managed patients, with improved outcome scores for the ABR group.<sup>28</sup> They again found higher return to the same level of sport (89% vs 53%) amongst the surgical managed group.<sup>28</sup> While the previous studies have shown that ABR following first-time dislocations results in superior outcomes, it has also been shown that a second dislocation prior to surgical repair also results in increased failure rates after repair. Fox *and colleagues* showed that the failure rates differed between patients with a single versus second dislocation prior to repair (16% vs 41%).<sup>29</sup> With the current literature showing a high risk of recurrent instability following nonoperative management, significant biomechanical and clinical impacts of repeated dislocation, and excellent outcomes following surgical repair after first time dislocation, there is strong evidence to support the recommendation of surgical repair following a first-time instability event to minimize risks of recurrence. Inherently, the recommendation for immediate surgical stabilization following a first-time event can come into direct conflict with immediate goals of the in-season athlete. Therefore, the risks of delayed surgical treatment should be compared to the importance of continuing in-season participation with each athlete on an individual basis.

## EVOLVING CRITICAL GLENOID BONE LOSS

Glenoid and humeral sided bone loss are known risk factors for recurrent instability. However, the values used to define “critical”, and “sub-critical” bone loss have continued to shift. While traditional values for critical glenoid bone loss were considered to be as high as 25%, this value has continued to decrease in recent years.<sup>30–35</sup> This decrease has been highlighted in multiple biomechanical, cadaveric, and clinical studies. Shin *and colleagues* recently argued for a lower threshold for critical glenoid bone loss based upon both cadaveric (15%) and clinical (17.3%) investigations, finding that values exceeding this threshold increase the risk of recurrent

instability, with a sensitivity of 75% and specificity of 86.6%, for ABR.<sup>32,33</sup> Similar studies in high risk patient population, such as the military and collegiate football players, have argued for a threshold of 13.5% due to an appreciated lower risk of recurrence and improved WOSI scores with ABR below this threshold.<sup>34,35</sup> These studies have largely focused on glenoid bone loss, but when considering additional risk factors, the threshold continues to decrease.<sup>17,36</sup> Cavalier *and colleagues* found that glenoid bone loss value of 10% was more appropriate critical value in patients 23 y old or younger for failure of ABR.<sup>36</sup> Further, Yang *and colleagues* found a similar 10% glenoid bone loss value when adjusting for age and previous instability surgery for when an open Latarjet reconstruction may be a preferred surgical option. Therefore, both studies suggest that when adjusting for additional risk factors, a lower critical glenoid bone loss value threshold should be considered for determining the appropriateness of ABR in this setting.

However, critical glenoid bone loss, while useful, does not account for the bipolar nature of the instability injury. Application of the glenoid track concept to the injury has become a useful tool for inclusion of the Hill-Sachs lesion in surgical decision-making.<sup>37,38</sup> The glenoid track, defined as the contact area between the humeral head and the glenoid as the arm moves through abduction and external rotation, has helped quantify the extent of bipolar bone loss and guide surgical management. However, while addition of remplissage for "off-track" lesions has been well-supported, it is clear that high risk sub-populations exist within the "on-track" population, further complicating the decision-making process.<sup>39,40</sup> The concept of distance to dislocation (DTD) has helped to identify patients who remain at high risk for recurrent instability despite having "on-track" Hill-Sachs lesions. With the addition of DTD, defined as the distance from the medial edge of the Hill-Sachs lesion to the medial edge of the glenoid track, a newer concept of the "near-track" lesion has been proposed.<sup>16,41,42</sup> Li *and colleagues* found that DTD less than 8 mm was predictive of failure after ABR, proposing that there is a "near-track" subset of "on-track" shoulders at higher risk for recurrent instability.<sup>42</sup> Expanding on this concept, Barrow *and colleagues* showed that at a threshold DTD of 10 mm, the risk of recurrent failure after ABR increased exponentially as DTD approached 0 or "off-track" values.<sup>41</sup> Boden *and colleagues* has reported that these "near-track" shoulders had even an

higher risk of failure following ABR in patients with hyperlaxity with nearly double the rate of recurrent instability and an OR of recurrent instability of 34.<sup>43</sup> Lin *and colleagues* showed that remplissage augmentation for ABR in "on-track" shoulders can be protective against recurrence in higher risk patients including those with "near-track" lesions who participate in contact sports.<sup>16</sup>

Glenohumeral bone loss is fundamentally 2 sided, and while the glenoid track and DTD concepts have significantly advanced our understanding of bipolar bone loss, neither concept truly characterizes or defines critical humeral-sided bone loss.<sup>37</sup> Cong *and colleagues* have proposed a new critical humeral bone loss value, defined by inferior craniocaudal extension of the Hill-Sachs lesion, measured as the lower edge angle greater than 90° in the sagittal plane, finding an OR for recurrent instability of 3.3 in those with inferior extension of Hill-Sachs lesions compared to those without.<sup>44</sup>

While the critical glenoid bone loss value remains subject to debate, values above 20% remain an indication for bone procedures such as anterior bone block or Latarjet, while the management of glenoid bone loss values between 10% and 20% may still benefit from additional procedures, including ABR with remplissage. New risk factors such as "near-track" lesions and inferior Hill-Sachs lesion extension will likely play a key role in management going forward, and further literature should seek to provide comprehensive analysis of these many risk factors to further guide the management process.

## SURGICAL DECISION-MAKING

Having considered the timing and associated risk factors for failure, the choice of surgical intervention inherently impacts postoperative recurrence rates. Treatment options for the management of anterior glenohumeral instability includes less invasive techniques such as ABR with or without the addition of remplissage, open Bankart repair with capsular shift, and open or arthroscopic bony restoration procedures such as Latarjet and free bone block transfers using autograft or allograft.

The open Bankart procedure has shown positive long-term results in the setting of anterior shoulder instability, including historically low rates of recurrent instability.<sup>45,46</sup> However, a recent biomechanic analysis of the open Bankart procedure performed in the setting of 10% glenoid bone loss showed considerable increases in

glenohumeral translational stiffness and reduction of humeral head rotation, which is an important consideration in those where range of motion is paramount, including overhead athletes.<sup>47</sup> ABR, on the other hand, remains the most commonly utilized surgical approach for managing anterior instability in the United States.<sup>6</sup> However, despite its popularity, studies have shown elevated failure rates, significantly lower outcome scores, and significant biomechanic alterations when performed in the setting of increasing glenoid bone loss, including values from 13.5% to 17.3%.<sup>32,33,35</sup> In these clinical situations, consideration of alternative stabilization procedures may be recommended due to these concerning rates of recurrence. As previously discussed, more recent literature suggests critical glenoid bone loss may be as low as 10%, particularly in high-risk populations such as young contact athletes.<sup>17,36</sup> As mentioned earlier, decision-making becomes increasingly more complex when considering humeral sided bone loss in the setting of glenoid bone loss and additional risk factors. Thus, one should evaluate glenoid and humeral bone loss in the setting of other specific patient risk factors, considered on an individual basis. In the absence of additional risk factors and significant glenoid and humeral bone loss, the choice of ABR in a first-time dislocator is appropriate and systematic reviews continue to show it lowers rates of failure with low complication rates.<sup>44,48,49</sup> Further, literature supports that surgical intervention continues to be superior to nonoperative management in this population, with 3.9 times higher rates of return to sport compared to immobilization.<sup>48</sup> Therefore, the area of debate and continued research exists in patients with glenoid bone or humeral loss and/or identified risk factors for instability.

The remplissage procedure, termed "to fill", was first described by Wolf *and colleagues* in 2007 as a supplemental technique to reduce the risk of recurrent anterior shoulder instability with anterior inferior glenoid bone loss and an engaging Hill-Sachs lesion.<sup>15</sup> The remplissage procedure secures the posterior infraspinatus and/or glenohumeral joint capsule into the Hill-Sachs lesion. While initially described as an augment for ABR in patients with "off-track" lesions and subcritical glenoid bone loss, it has become a popular adjunct for ABR for "on-track" shoulders and is considered a safe and effective treatment option in multiple patient populations. Multiple studies in patients with anterior instability with "on-track" Hill-Sachs lesions have demonstrated lower rates of

recurrent instability when compared to arthroscopic labral repair alone.<sup>16</sup> Further, in vitro biomechanic analyses of remplissage have shown increased glenohumeral stability at the expense of potentially decreased shoulder range of motion, specifically external rotation.<sup>50</sup> In a recent biomechanic analysis investigating the augmentation of ABR with dynamic anterior stabilization or remplissage procedure, both the remplissage and dynamic anterior stabilization significantly reduced residual anterior instability compared to isolated ABR in models with bipolar bone loss, largely restoring native glenohumeral stability under most translational loads. Further, remplissage was found to be effective at decreasing anterior translation for "on-track" lesions, but may potentially limit the range of motion for "off-track" lesions.<sup>51</sup>

Overall, remplissage continues to gain traction as a useful adjunct to ABR in higher risk patients, including contact athletes with "near-track" lesion or reduced DTD, critical humeral bone loss, and sub-critical glenoid bone loss (<20%). There is significant evidence supporting the use of remplissage in patients with "off-track" lesions.<sup>37,52</sup> For example, a recent systematic review demonstrated a 9-fold decrease in recurrent instability when adding remplissage to patients with "off-track" lesions.<sup>52</sup> Concerns remain regarding external rotation loss and overall function with remplissage, specifically in overhead athletes. Pawluś *and colleagues* found a statistically significant decrease in external rotation of  $-1.4^\circ$  with comparable WOSI and Rowe scores when comparing those undergoing ABR with remplissage to those undergoing ABR alone.<sup>52</sup> In addition, systematic reviews that expand their criteria for remplissage to include both "on-track" and "off-track" patients, have found a significant reduction in recurrent dislocations and revision procedures compared to ABR alone.<sup>53</sup> Therefore, the remplissage has become increasingly popular to minimize risks of recurring following ABR in all circumstances including "on-track" shoulders. However, the adoption of remplissage to all ABR may lead to unintended consequences. Thus, the question arises, when does one add remplissage to ABR? As previously discussed, a method of analysis that takes a comprehensive approach to the entirety of the injury may be beneficial in guiding management decisions. Charles *and colleagues* has proposed a Pittsburgh Instability Tool (PIT) that aims to predict patient populations who may benefit from the addition of a remplissage to ABR for "on-track" shoulders versus those suited for an ABR alone versus those who would

benefit from an alternative approach to ABR with or without remplissage.<sup>54</sup> This analytical tool allows for “scoring” of preoperative risk factors such as contact athlete status, number of prior dislocations, hyperlaxity, age, DTD status, or percent glenoid bone loss, putting patients in risk categories for recurrent instability and showing the impact on this risk with the addition of remplissage.<sup>54</sup>

In patients with significant ligamentous hyperlaxity and recurrent anterior instability in the setting of advanced glenoid bone loss, isolated soft tissue stabilization has been associated with elevated failure rates.<sup>55</sup> The Latarjet and bone block procedures have been demonstrated to be superior in these circumstances compared to ABR with respect to recurrences and patient-reported outcomes (PROs).<sup>13,56</sup> Both arthroscopic and open techniques of the Latarjet procedure have been analyzed from a biomechanic perspective. Notably, in 2013, Yamamoto and colleagues demonstrated that the Latarjet procedure provides superior stabilization in those with anterior instability, especially in the presence of advanced glenoid bone loss.<sup>57</sup> The primary stabilizing mechanism of Latarjet, identified as the “sling effect”, is often attributed to the subscapularis and conjoint tendons during mid- and end-range arm positions.<sup>57</sup> Another study highlighted that both arthroscopic and open Latarjet procedures substantially reduced

humeral head translation when addressing combined anteroinferior glenoid and capsular defects.<sup>58</sup> In this study, the open Latarjet technique provided a superior stabilizing effect compared to the arthroscopic approach, particularly in the abduction position.<sup>58</sup> However, no significant differences in stabilizing effects were observed between the open and arthroscopic approaches in the abduction external rotation position.<sup>58</sup> With regards to return to sports, systematic reviews have neither identified a difference in return to play, nor timing to return to play between ABR and open Latarjet.<sup>59</sup>

In patients with critical glenoid bone loss, free bone block procedures, such as distal tibial allograft, iliac crest autograft, and distal clavicle autograft, can also be considered in addition to the Latarjet. Systematic reviews have shown similar recurrence, reoperation, and complication rates to that of the Latarjet.<sup>56,60</sup> The ideal graft is unclear, with comparable outcomes between autografts and allografts.<sup>61</sup> One of the primary concerns and areas of research is graft resorption and its impact on outcomes, as this has been shown to occur more commonly when using allograft.<sup>62</sup> Graft preparation and fixation techniques are becoming increasingly important in preventing graft resorption and subsequent hardware-related complications.<sup>63</sup>

The indications for each treatment option are paramount, as optimizing patient and technique

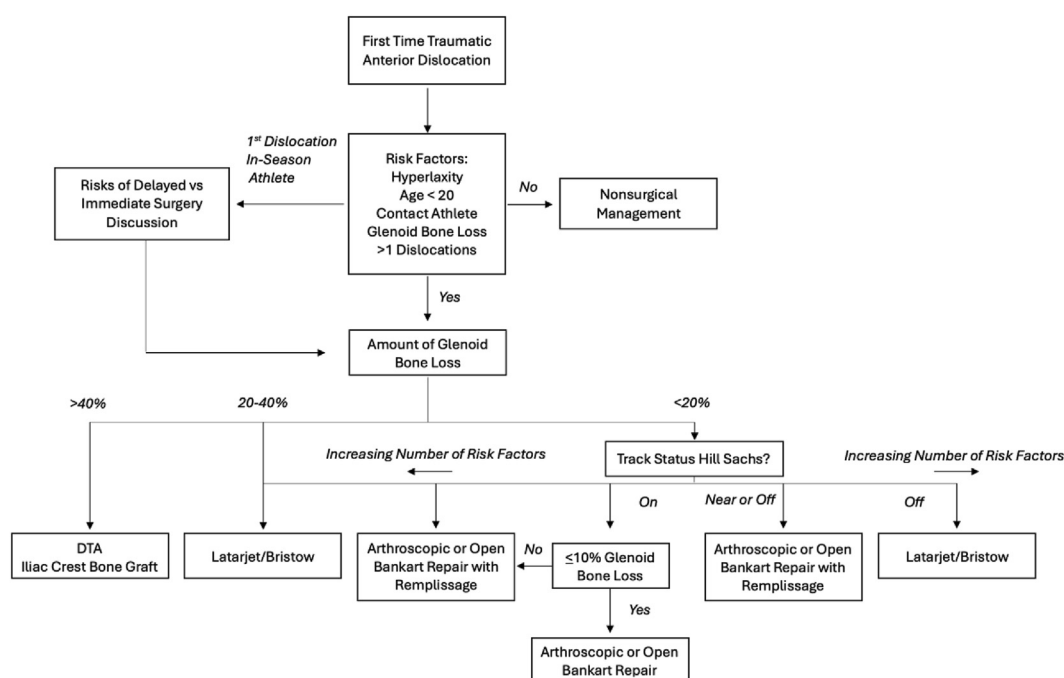


Fig. 1. Author’s proposed treatment algorithm for first time traumatic dislocations.

selection is necessary for optimizing outcomes while minimizing failure rates. For instance, an open Bankart repair is typically favored in a patient with a higher number of recurrent dislocations and minimal bone loss, emphasizing the importance of capsular shift, while Latarjet is more often favored in a patient with critical glenoid bone loss or in the revision setting, after failed arthroscopic or open capsulolabral repair.<sup>6,64</sup> Addition of a remplissage is typically indicated in the presence of an engaging Hill-Sachs defect, or those with “on-track” defects with reduced DTD or additional risk factors such as hyperlaxity, contact sports, or critical humeral bone loss.<sup>64</sup>

## SUMMARY

While the optimal surgical technique to address various severities of anterior glenohumeral instability remains subject to debate, recent literature has advanced our understanding of additional risk factors for failure with primary ABR, including contact athletes, reduced DTD, and critical humeral bone loss.<sup>65</sup> When managing the in-season athlete with anterior instability, the risks of delayed surgical treatment should be compared to the importance of continuing in-season participation with each athlete on an individual basis. Surgical treatment approaches must be made on an individual basis, taking into consideration known risk factors for recurrence, presence of glenoid bone loss, and established bipolar bone loss models such as the glenoid track and DTD concepts (**Fig. 1**). With the ever-growing complexity and understanding of risk factors for recurrent instability, there is an increasing role for decision-making tools, such as the PIT scoring tool, to allow surgeons to properly weight the impact of each risk factor, and apply the potential benefit of additional procedures such as remplissage. To truly maximize clinical outcomes and minimize recurrent instability rates, surgeons must consider all aspects of the clinical scenario, including patient-specific risk factors, the extent of pathology, indications of available treatment options, and individual patient activity goals.

## CLINICS CARE POINTS

- Athletes choosing to return to play in the same season who suffer a second in-season instability event have higher odds of failure following surgical stabilization compared to immediate surgical fixation.

- Operative stabilizations in the off-season athlete have excellent rates of return to play with patients more likely to complete the subsequent season compared to those undergoing nonoperative management.
- There is increasing evidence of a role for additional stabilization procedures such as remplissage in patients with glenoid bone loss between 10% and 20%.
- Decision-making tools, such as the PIT scoring tool, allow surgeons to properly weight the impact of each risk factor, and apply the potential benefit of additional procedures.

## DISCLOSURE

The authors have nothing to disclose.

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