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Review Article

Bone Block Techniques in the Treatment of the Anterior and Posterior Instability of the Shoulder

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Abstract

Glenoid and humeral head bone defects are frequent findings in the gleno-humeral instability of the shoulder and can significantly affect the outcome of the surgical treatment. Soft tissue repair alone is often insufficient to achieve joint stability. In the anterior instability the incidence of glenoid defects can reach 88%; in the posterior dislocations the glenoid bone loss affects about 5%. The repair of bone defects makes use of numerous surgical options, both in open surgery and arthroscopy. to treat both the anterior and posterior instability several anatomical areas are described for harvesting a bone block. Imaging helped to quantify the bone loss for a better decision-making algorithm but lacked the guidelines and availed limited short-to-medium-term case studies.

Keywords: *Shoulder; Instability; Bone Block Technique; Algorithm*

Introduction

In gleno-humeral instability, the presence of glenoid and/or humeral bone fractures and defects is a frequently reported problem. In anterior gleno-humeral dislocation, glenoid defects can be present up to 22% of cases and up to 88% in recurrent instability, with a significant reduction of the resistance to axial forces. The glenoid bone loss is therefore the cause of bad results after arthroscopic or open capsuloplasty, since soft tissue repair alone may be insufficient to stabilize the shoulder. In the posterior gleno-humeral dislocation, the glenoid bone loss accounts for 3 - 4% of all dislocations. Detachment of the posteroinferior labrum with capsular elongation can lead to insufficiency of the posterior band of the inferior gleno-humeral ligament. Bone lesions range from reverse bony bankart, to glenoid erosion, to posterior glenoid dysplasia or to "reverse" Hill Sachs; they can contribute, if not recognised and treated, to the clinical failure. Imaging can quantify glenoid and humeral bone defects and monitor the evolution of bone graft techniques. Treatment of posterior bone loss includes several surgical options, from the posterior glenoid bone graft, to the glenoid osteotomy or capsulo-tendon transfer. Open surgery through deltoido-pectoral access has recently been followed by several arthroscopic techniques [1] with great benefits as they allow greater respect for periarticular anatomy in the stabilization of the shoulder. In fact, in the last 10 years arthroscopic techniques have overcome the initial disadvantage of treating significant bone defects, reserved for open surgery [2].

Anterior glenoid bone loss

Bigliani., *et al*. described four types of anterior glenoid defects, namely type 1 with non dislocated anterior glenoid fragment; type 2 with small dislocated fragment; type 3 with anterior glenoid bone loss < 25% and type 3b with anterior glenoid bone loss > 25%. For the

types 1, 2 and 3a, the Author recommends a reconstruction of soft tissues, while for type 3B the bone block procedure [3]. Bone loss greater than 20 - 25% alter the shape of the glena defined by Burkhart "inverted pear" [4]. Loss of anterior inferior glenoid arc morphology decreases resistance to dislocation [5].

The "glenoid track" [6] combines the glenoid and humeral defects for which the defects are classified in on-track and off track [7]. Treatment algorithms depend on many factors, but the size and type of glenoid bone defect (fragment or erosion) are a priority. If anunstable bone fragment is associated with a labral tear, arthroscopic repair is indicated despite the size of the fragment, both in acute and subacute fracture [8]. In cases of bone loss, there are no precise guidelines today. If the bone deficit is more than 20% higher than the healthy controlateral glenoid, an open or arthroscopic bone block procedure is recommended to anatomically reconstruct the glenoid arc [9]. A bone loss of less than 20% associated with an Hill Sachs lesion located off the glenoid track can be treated with bone block procedures [10]. In addition to the classification of bone defects, ISIS-score considers other risk factors that can preclude arthroscopic or open capsuloplasty; when the severity score of the ISIS-score is more than 6 points, the isolated soft tissues reconstruction is not indicated especially in the long term [11].

Surgical techniques for the anterior glenoid bone loss

The main donor sites are represented mainly by the iliac crest (bi- or tricortical bone graft), the coracoid process of the scapula in part or entirely, the distal clavicle, the lateral acromion and finally the lateral distal portion of the tibia [12-14].

Iliac crest

It is historically the most used, especially for large glenoid defects in the anterior instability with bone loss of more than 25-30% and in the treatment of failed Latarjet [15].

Warner., *et al.* documented the adaptation of the tricortical graft on the concaveness of the glenoid, without osteolysis or reabsorption of the graft with a follow-up of 4-6 months, and no recurrence rates with an average follow-up of 33 months [16]. Auffarth. *et al*. described a variant with a J-shaped bicortical iliac crest graft and press fix positioned in a medially prepared box on the glenoid edge, without recurrence at 7.5 years of follow-up [17].

Coracoid process of the scapula

The transfer of the apex of the coracoid (Bristow) or the entire coracoid (Latarjet) on the anteroinferior glenoid neck, have traditionally been carried out as open procedures. Latarjet procedure represents the most used in case of bone loss > 25% and in cases the recurrence of Bankart repair [18]. Recently Lafosse describes the arthrolatarjet technique [19] and new arthroscopic techniques have been described involving the placement and fixation of a bone graft on the anterior-lower region of the glenoid. The Sheffield bone block procedure describes the harvest of the medial part of the coracoid deprived of its muscle insertion and fixed to the anteroinferior glenoid with two screws [20].

Distal tibia

Provencher. *et al.* originally described the technique using a lateral portion of the distal tibia in large bone defects that cannot be reconstructed according to Latarjet. The bone graft of the distal tibia in fact has a warp radius similar to the curvature of the native glenoid, allowing optimal adaptation. Authors in 27 patients reported a marked clinical improvement without recurrence at an average follow-up of 45 months. The average percentage of allograft osteointegration was 89% with an average osteolysis rate of 3% to 1.4 years of follow-up [21].

Acromion process of the scapula

The original technique involves the removal of two cylindrical grafts from the lateral side of the acromion, recently used in arthroscopy. Arthroscopy, although technically challenging, allows the reconstruction of glenoid bone defects and the osteosynthesis of some glenoid fractures. The technique described by Mochizuki. *et al.* involves the removal of two cylindrical grafts from the lateral side of the acromion and their fixation with suture anchors [22].

Distal clavicle

Another location for bone block harvest is the lateral part of the clavicle, a technique recently performed by arthroscopically assisted techinique. Tokish. *et al.* described the removal of 6 - 8 mm of the lateral part of the clavicle, fixed to the glena with suture-anchors or with a 3.75 mm. cannulated screw. The graft provides an anatomic reconstruction of the antero-inferior glenoid and has a large surface area for fixation. Short-term results on a small group of patients were good [23]. A biomechanical study reported by Petersen., *et al.* assessed differences in pressure and contact between the lateral clavicle graft and a coracoid bone graft with final results of identical efficacy [24].

Several Arthroscopic assisted techniques for bone anterior glenoid bone loss are described ; according to Scheibel., *et al.* [25] the bone graft is taken from the iliaic crest, shaped to restore the lower glenoid morphology, positioned on glenoid bone loss level, using three anterior portals and fixed with K wires temporarily and stabilized with two cannulated compression screws; two anchors, one superior and one inferior to the graft, are used to perform capsuloplasty and to complete the repair.

Nebelung. *et al.* [26] describe an arthroscopic technique for bone loss of more than 20%, measured with CT scans according to the criteria described by Sheibel. *et al.* The technique describe the removal of part of the iliac crest (Figure 1) and its positioning through the rotator interval with shuttle sutures at the level of the defect (Figure 2) and fixed with biodegradable or titanium double helix screws. Finally, the capsulolabral complex is repaired with one or two reabsorbable suture-anchors (Figure 3). According to the authors the technique recreates the anatomy of bone and capsulolabral tissues of the antero-inferior glenoid. Preliminary results on 24 patients with an average follow-up of 19 months showed X-ray healing (Rx and/or CT) of the bone block in all cases in absence of dislocation recurrence. Taverna., *et al.* described the procedure of arthroscopic bone block with iliac crest autograft, associated with capsuloplasty with suture anchors. At 5 years of follow-up in 32 patients there were no recurrences of instability or reabsorption of the graft, with satisfaction about the function and the Range of Motion (ROM) [27,28]. Taverna recently modified the technique, fixing the graft from the iliac crest using four Endobuttons (Figure 4), through the cannula in the rotator interval on the anteroinferior glenoid rim (Figure 5), using a dedicated glenoid guide (Figure 6). Finally, the anterior labrum, capsule and ligaments are reinserted with suture-anchors [29].

Figure 1: *Iliac bone block prepared with the arthroscopic technique described by Nebelung.*

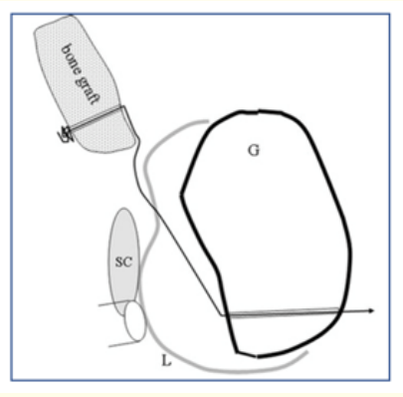

Figure 2: *The bone block is introducted into the joint according with the technique described by Nebelung.*

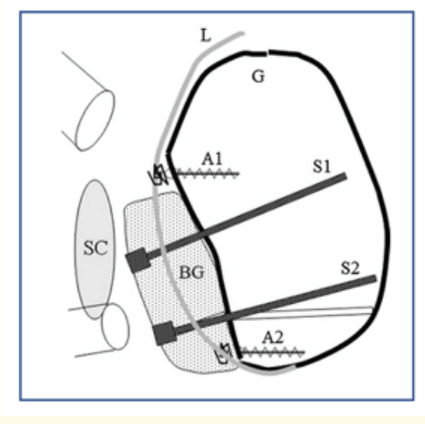

Figure 3: *Bone block fixation and capsuloplasty according the Nebelung technique.*

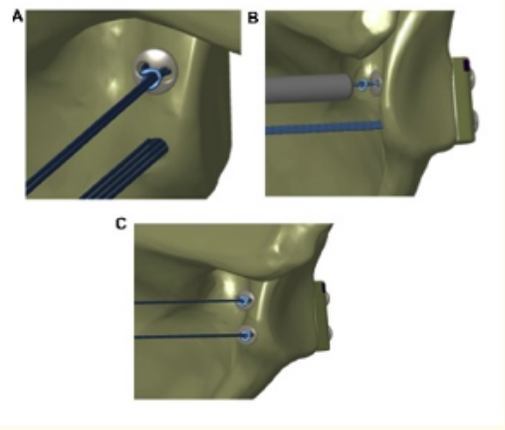

Figure 4: *Bone block fixation according with Taverna technique with special endobuttons.*

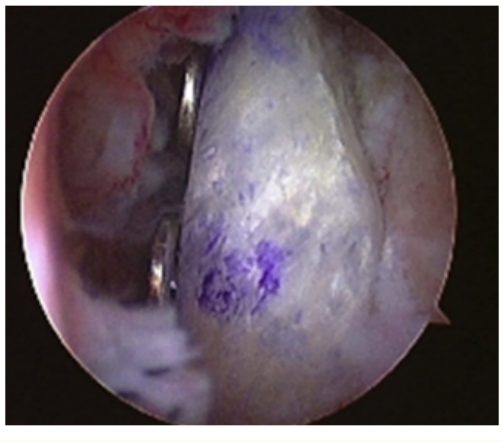

Figure 5: *Arthroscopic view of the anterior glenoid bone block in place. (kind concession Taverna E.).*

Figure 6: *The new Smith and Nephew glenoid guide used in the technique described by Taverna.*

Posterior glenoid bone loss

Posterior instability of the shoulder accounts for about 2-5% of all glenohumeral instabilities [30]. In the posterior dislocations bone defects are more common on the humeral side than in the glenoid. McLaughlin was the first to describe osteocondral defects on the anterior part of the humeral head [31]. The presence of a bone defect significantly increases the risk of recurrence as well as a defect on the glenoid side [32]. Wirth., *et al.* have shown that the posterior translation is very sensitive to small posterior glenoid defects or retroversion that increases significantly with 5° of posterior glenoid bone loss, corresponding to about 2.5° of glenoid retroversion [33]. Since the reverse Hill-Sachs are larger than the Hill-Sachs, there is a general consensus on the reconstruction of a bone lesion greater than 10% of the joint surface.

A recent systematic review highlighted the lack of guidelines on bone defects to be treated with bone procedures and the correlation between the extent of loss and the risk of recurrent dislocation [34]. Open bone blocking procedures have been proposed to treat both glenoid and humeral defects. Open techniques require extensive and demanding access with suboptimal cosmetics and the possibility of partial postoperative failure of the deltoid muscle [35]. In addition, the correct placement of the graft can be difficult or impossible with an open method, to treat reverse Hill-Sachs and glenoid labrum lesions including Slap lesions, taking advantage of arthroscopic techniques of posterior bone block.

Surgical techniques for the posterior bone loss

Reconstructions of capsule-labrals tears find indications with normal glenoid bone anatomy; techniques have been described for the treatment of traumatic posterior bony bankart, posterior glenoid erosion and posterior glenoid dysplasia [36-38]. Unlike the anterior bone loss, in the posterior instability there is a high recurrence rate after soft tissue repairs, even in the absence of posterior bone loss [39-41]. The homolateral iliac crest is the usual location of bone removal to extend the glenoid surface rather than to reconstruct an anatomical defect; posteroinferior capsulo-labral repair improves the postero-inferior joint stability. Unlike the anterior instability, the relationship between the effect of the posterior bone loss and the severity of posterior instability has not yet been determined. For the traumatic dislocations, a triangular bone defect (Delta) has been described, for the atraumatic instabilities, a defect of rounded shape (Lazy) [42,43]. Hindenach in 1947 described the procedure of posterior shoulder stabilization with a posterior bone graft [44]. Numerous subsequent studies have been published with varying results. Levigne., *et al.* reported a series of 29 patients (31 shoulders) at 33 months follow up, operated with a posterior bone block and with additional open capsulorrhaphy in 80% of cases [45].

Servien., *et al*. published the results with the same method for a series of 21 patients with an average follow-up of 6 years [46]. Meuffels., *et al.* they analysed 11 patients treated with open posterior bone block with a follow-up at 18 years [47]. Lafosse., *et al.* In 2012 they described a an arthroscopic posterior bone block technique associated with capsulolabral reconstruction with the use of the instrument for the arthroLatarjet described by Lafosse and Boyle [48].

Wellmann., *et al.* they used the same technique performed on 18 patients (24 shoulders); through a vertical capsulotomy with radiofrequency and abrasion of the posterior glenoid neck, the tricortical bone block harvested by the omolateral iliac crest is positioned and fixed in place at the posterior glenoid neck with 2 cannulated metal screws associated to the reconstruction and plication of the posterior capsule with absorbable suture anchors [49]. Schwartz., *et al.* reported the results of 18 patients treated with arthroscopic posterior bone block with a similar technique [50].

Discussion

The Anterior glenoid bon loss is a major cause of anterior shoulder instability. Advanced imaging technologies have greatly improved the diagnosis and quantification of bone loss for the surgical decision algorithm. From the open techniques of Bristow-Latarjet has moved to the arthroscopic ones, with follow-up not exceeding five years as for the traditional Latarjet. About the accuracy of the placement of the coracoid bone graft in the Latarjet open compared to the arthroscopic Latarjet, Russo., *et al.* showed that there are no statistically significant differences except for the coronal positioning in favour of the Latarjet open [51]. In parallel with these methods, arthroscopic bone block options have been added with different ways of transfer and graft fixation to recreate the geometry of the native glenoid and reduce the risk of recurrent instability and glenohumeral osteoarthritis [52]. The Latarjet procedure remains the golden standard for its very high long-term success rates [18]. Unlike in bone block open techniques, the most technically difficult phase of the arthroscopic methods involves the transfer of the graft into the joint and its correct positioning [26]. The instruments inserted through the anterior portal and the rotational range not only do not allow the optimal placement of the graft but limit the vision of the operating field. Dragging the graft with the trans glenoid sutures through the rotator interval facilitates the bone block procedure [29]. The effectiveness of this procedure

is related to the tricortical graft that restores the native glenoid morphology and capsulo-labral reconstruction with suture-anchors that restores the anatomy of soft tissues [26,28].

Finally, endobuttons are less invasive and with fewer complications than metal screws, about damage to the subscapularis muscle, nerve injuries, tumefaction or bleeding [29]. In the failures of Latarjet techniques or with very extensive bone loss, the classic grafting of the iliac crest or distal tibia represent valid reconstruction options; Although the rate of bone graft reabsorption is high, the functional result and recurrence rate are good in most patients [14,15].

In the posterior glenoid bone loss, the bone block associated with arthroscopic capsuloplasty seem to give safe results for stability and pain resolution. After reconstruction of soft tissues only in cases of glenoid dysplasia and glenoid posterior bone loss, recurrent posterior instability reappeared frequently [53,54]. Tibone., *et al*. report a recurrence rate of 30% in sportive patients after posterior capsuloplasty [41].

Although the soft tissue reconstructions to treat the posterior glenohumeral instabilities showes good results [55,56], Mauro ad al. showed an increased risk of recurrence after capsuloplasty in patients with a small anteroposterior glenoid, then requiring stabilization with posterior bone block. The group of patients treated with the posterior bone block is not omogeneous, ranging from the treatment of severe posterior glenoid defects to the insufficiency of soft tissue after capsulolabral repair [54]. Levigne., *et al.* report the results on a series of 31 shoulders, at 33 months of follow up, treated by open posterior bone block and posterior capsuloplasty in 80% of cases, with a high satisfaction rate (74% very satisfied, 26% satisfied), despite the presence of a recurrence rate of 13% and partial lysis of graft by 23% [45]. Servien., *et al*. published a series of 21 cases at 6-year follow-up with good and excellent results, despite residual posterior instability [46].

Meuffels., *et al.* reported on a series of 11 patients at 18 years follow up a recurrence rate of 36% and osteoarthritis in all cases, with worsening clinical results after 6 years [47]. Recent arthroscopic procedures have developed to improve the technique of posterior bone block.

Schwartz., *et al.* they analysed the results in 18 patients treated with bone block and posterior arthroscopic capsuloplasty. An improvement was found at 20 months, with dissatisfaction in only 2 patients. The osteolysis of the block required the removal of the screws in 6 cases, for soft tissue flogosis in the region of the infraspinatus tendon. The additional posterior capsuloplasy was carried out only in two cases, with no recurrent dislocations or subluxations [50]. Boileau., *et al.* published the clinical results at 18 months in a group of 15 patients sottoposed to arthroscopic capsulolabral repair and posterior bone block fixed with suture anchors to avoid the removal of metallic hardware. In the absence of recurrent instability, CTscan after 6 months demonstrated partial reabsorption in the upper half of bone grafts in all cases. This group of patients was heterogeneous, with and without bone loss and a clinical spectrum ranging from complete dislocations to recurrent subluxations [57]. Posterior bone block procedures are relatively rare and available studies show good short-term results, but are related to small heterogeneous populations of patients [58,59].

In conclusion, glenoid and/humeral bone defects represent in the anterior and posterior gleno-omeral instability a problem not easy to solve and require a great experience of the surgeon. Imaging in recent decades has helped to formulate decision-making algorithms to minimize recurrences. Treatment of glenoid and humeral bone loss in anterior or posterior instability is considered necessary, although there are few studies related to specific surgical procedures. Medium and long-term studies are needed on more homogeneous patient groups to assess recurrence and secondary osteoarthritis rates, standardizing the method to study the integration or the resorption of the bone graft, mainly through CTscan with 3D reconstructions [60,61].

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