


## CLINICAL ARTICLE

# Risk Factors of Graft Resorption after Arthroscopic Autologous Scapular Spine Bone Graft for Recurrent Shoulder Instability

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**Objective:** To analyze if general factors such as age, gender, dominant side, fasting blood sugar level, BMI (body mass index), smoking, and drinking play a role in graft resorption after arthroscopic autologous scapular spine bone grafting.

**Methods:** From July 2016 to August 2018, patients who were diagnosed with anterior shoulder instability with subcritical bone loss (10%–15%) and underwent arthroscopic autologous scapular spine bone graft transplant were retrospectively reviewed and enrolled in this study. The age, gender, dominant side, fasting blood sugar level, BMI, smoking, and drinking conditions of the enrolled patients were recorded. The graft resorption rate at postoperative 1 year was also measured on three-dimensional computed tomography (3D-CT) scans. The Pearson test and the Spearman test were used to identify any significant correlation between the general factors and graft resorption rate.

**Results:** A total of 27 patients who underwent arthroscopic autologous scapular spine bone graft for recurrent shoulder instability qualified and were included in this study. There were 20 males and seven females, the mean age was  $30.8 \pm 9.4$  years, the mean follow-up time was 29.3 months (range, 25–39 months), during which no severe complications such as infection, neurovascular injury, or re-dislocation were observed. The bone graft healed in all cases, the mean healing time was  $2.6 \pm 0.5$  months (range, 2–3 months). At the last follow-up, the mean Constant–Murley score was  $89.74 \pm 3.71$ , the mean Disabilities of Arm, Shoulder and Hand (DASH) score was  $9.77 \pm 5.31$ , and the mean visual analogue score (VAS) was  $0.74 \pm 0.64$ . The apprehension test was all negative at final follow-up. The fasting blood sugar level was  $4.78 \pm 0.42$  mmol/L, BMI was  $23.70 \pm 4.70$ . Five patients were “smoking” and 22 “non-smoking”, four patients were “drinking” and 23 were “non-drinking.” The graft resorption rate at postoperative 1 year was  $19.4\% \pm 7.5\%$ . The Pearson test and the Spearman test showed no significant correlation between age, gender, dominant side, fasting blood sugar level, BMI, smoking, drinking, and graft resorption rate.

**Conclusion:** Age, gender, dominant side, fasting blood sugar level, BMI, smoking, and drinking were not significantly correlated with graft resorption after the arthroscopic autologous scapular spine bone graft for recurrent shoulder instability.

**Key words:** Scapular spine; Recurrent shoulder instability; Arthroscopy; Graft resorption

## Introduction

Anterior shoulder instability is quite common in sports medicine. It seriously affects patient's daily life and sports ability. Currently, surgical treatment is the first choice for the treatment of anterior shoulder instability especially

for arthroscopic surgery. Commonly, the surgery techniques include soft tissue surgery such as Bankart repair, remplissage procedure and bony surgery such as Bristow–Latarjet procedure (autologous coracoid bone graft) and Eden–Hybinette procedure (autologous iliac crest bone

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graft). The size of glenoid bone loss is always the key reference index for the choice of surgical methods. Simply, Bankart repair is unreliable to restore the glenohumeral stability when the glenoid bone loss is more than 10%<sup>1, 2</sup>. Bristow–Latarjet procedure, with its modifications, is effective in treating significant glenoid bone loss, while its frequent complications and risks may lead to poor clinical results<sup>3, 4, 5</sup>. Thus for anterior shoulder instability with subcritical glenoid bone loss (10%–15%), the Bankart repair is unable to reconstruct the bony structure and may lead to higher failure rates while Bristow–Latarjet procedure would lead to overtreatment and higher potential complications. Recently, we described a technique of arthroscopic autologous scapular spine bone graft for recurrent shoulder instability with subcritical (10%–15%) glenoid bone loss<sup>6</sup>. This technique has been proven to be safe and effective by the short-term clinical and radiological results.

For bony procedure in treating anterior shoulder instability, the bone graft resorption is the main concern. High graft resorption rate would cause failure of surgery and risks of shoulder re-dislocation. Besides, graft resorption would also cause postoperative stiffness, pain, and shoulder instability<sup>7, 8, 9</sup>. However, with its effectiveness in treating anterior shoulder instability, bonegraft resorption occurs in scapular bone graft as well, just like Latarjet procedure and Eden–Hybinette procedure. Studies have explored the risk factors for graft resorption after Latarjet procedure, especially the biomechanical relationship between glenoid and coracoid bone graft (mainly the compression of the interface between the graft and the glenoid)<sup>10</sup>. Other studies have implicated the influence of unevenly distributed blood supply on graft resorption<sup>11</sup>. They believe the blood supply in superior part of the bone graft is poorer than that in inferior part, thus the graft resorption mainly occurs in the superior part. Almost all studies of interest have focused on the local environment around the glenoid and bone graft as well as their surrounding biomechanical stress, while general conditions have rarely been taken into consideration, such as age, gender, dominant side, fasting blood sugar level, BMI (body mass index), smoking, and drinking. Previously, these factors are studied and thought to be correlated to bone resorption in fracture healing process, among which smoking is thought to be extremely harmful for bone healing and aging is also thought to be disadvantageous for bone healing. Essentially, the bone healing and resorption in bone grafting shares the similar biomechanical process with that in fracture healing. Thus, the bone graft resorption may be influenced by these general factors as well. Further, the scapular spine bone graft is analogous in location with coracoid bone graft yet the bone growing environment and biomechanical condition varies significantly, thus it's arbitrary to speculate the graft resorption of scapular spine bone graft with that of coracoid bone graft. Studies need to be conducted to investigate if the general factors play a role in graft resorption after arthroscopic autologous scapular spine bone graft for anterior shoulder instability.

Therefore, the purpose of this study is to: (i) calculate and record the scapular bone graft resorption rate at postoperative 1 year after the arthroscopic autologous scapular spine bone graft for anterior shoulder instability; (ii) retrospectively review the correlation between the bone resorption rate and the age, gender, dominant side, fasting blood sugar level, BMI (body mass index), smoking, and drinking; (iii) identify the safety and effectiveness of arthroscopic autologous scapular spine bone graft for recurrent shoulder instability.

## Materials and Methods

From July 2016 to August 2018, patients who were diagnosed with anterior shoulder instability with subcritical bone loss (10%–15%) and underwent arthroscopic autologous scapular spine bone graft transplant were retrospectively reviewed and enrolled in this study. The glenoid bone loss was evaluated by the method described by Sugaya<sup>12</sup>.

The inclusion criteria were: (i) patients who were diagnosed with anterior shoulder instability with glenoid bone loss between 10% to 15%; (ii) arthroscopic autologous scapular spine bone graft was performed to treat shoulder instability; (iii) three complete sets of CT scans (preoperative, postoperative 1 week, and postoperative 1 year) were available; (iv) preoperative general factors including age, gender, dominant side, fasting blood sugar level, BMI, smoking, and drinking conditions were available; (v) clinical follow-up time was at least 2 years.

The exclusion criteria were: (i) concomitant rotator cuff tear; (ii) concomitant remplissage or SLAP repair; (iii) previous surgery of the affected shoulder; (iv) open surgery.

## Demographics

Patients who were enrolled in this study were meticulously reviewed, including their age, gender, dominant side, fasting blood sugar level, BMI, smoking, and drinking. The age refers to the patient's age when they underwent the surgery. If the surgery side was the dominant side of the patient, then we considered it as "dominant side," otherwise we considered it as "non-dominant side." The fasting blood sugar level refers to the blood sugar level taken the next morning after admission when the patient was in fasting. The BMI was measured and calculated at the time of admission. If one patient did not quit smoking in the past 3 years, then we considered this patient as "smoking," otherwise we considered this patient as "non-smoking." The same criteria was also applicable for the "drinking" judgment, but additionally only when the patient drank more than three times a week (on average) could he/she be considered as "drinking," otherwise they were considered as "non-drinking."

## Surgical Technique

The details of surgical technique are described in previous study<sup>6</sup>.

### Anesthesia and Position

After general anesthesia, the patient was set in lateral decubitus position. The shoulder was positioned in abduction at 60°-70° and flexion at 10°-15°.

### Approach and Anchor Implantation

Establishment of the posterior portal and routine examination was performed. Then the anteroinferior and anterosuperior portals were established successively under the guidance of the needle. The scope was switched to anterosuperior portal, the labrum was elevated from the glenoid neck and resurfaced the edge of the anterior glenoid with a shaver or burr. Two anchors (Andover, Massachusetts, USA) were implanted as “graft anchor” at half past 3:30 and half past 4:30 (right shoulder). An additional one or two anchors were implanted at suitable places as “labral anchors.”

### Scapular Spine Bone Graft Retrieval and Graft Fixation

At the middle point of the scapular spine, one straight incision about 4 cm was made along the long axis of the spine. The soft tissue was carefully dissected and the bone was exposed, then a tri-cortical bone graft about 20 mm x 10 mm x 8 mm was harvested with an osteotome or a saw. A 1.5 mm K-pin was used to establish two bone tunnels within the graft, and one limb of each “graft anchor” was shuttled through the tunnel; the graft was then slid into the joint with the help of a cannula. All of the limbs of not only “graft anchor” but “labral anchor” were shuttled through the corresponding labral tissue and the graft was secured by firmly tying the suture. Figure 1 illustrates the fixation of scapular spine bone graft.

### Graft Resorption Measurement

#### Glenoid Bone Loss Measuring Method

In the actual glenohumeral joint biomechanical environment, it is the graft area on en face view that works as a blocker to prevent the humeral head shifting anteriorly. Thus, the depth of the bone graft (the length from the medial edge to lateral edge) is not meaningful when calculating the “graft resorption” that is influential for the stability of humeral joint. So, different from the measurement method we used before<sup>6</sup>, we adopted a new method, described as follows.

The humeral head subtracted three-dimensional (3D) computed tomography (CT) scans were obtained at preoperation, postoperative 1 week, and postoperative 1 year. The measurement of resorption of bone graft is a modification of that described by Sugaya<sup>12</sup>. First we approximately drew an outer-fitting circle on the inferior glenoid articular face on the 3D CT scans in image software (INFINITT, China). Then we used the tracing function to outline the area of the glenoid bone loss; thus, the percentage of the bone loss as accounted for by the circle area was calculated by the software. With this method, percentages of glenoid bone loss at each stage



**Fig. 1** The fixation of scapular spine bone graft. The suture limbs of anchors that were implanted within glenoid were shuttled through the osseous tunnels in scapular spine bone graft and the corresponding labrum, then the graft was fixed firmly by tying the suture. 1, Acromion; 2, Coracoid; 3, Glenoid; 4, Scapular spine bone graft.

(preoperative, postoperative 1 week, and postoperative 1 year) were calculated.

#### Resorption Rate (OR) Calculation

Due to the measuring method aforementioned, the percentage of glenoid bone loss at preoperation was calculated and recorded as “L,” the percentage of the glenoid bone loss at postoperative 1 week was calculated and recorded as “L1w,” and the percentage of the glenoid bone loss at postoperative 1 year was calculated and recorded as “L1y.” Finally, the resorption rate was calculated as follows: resorption rate (OR) = (L1y - L1w) / (L - L1w) \* 100%.

Additionally, with the same method, one independent observer measured the bone loss twice (with a time interval of 3 months) at each of the three time points (preoperation, postoperative 1 week, and postoperative 1 year), and the mean value of each time point was obtained and taken into final OR calculation.

#### Statistical Analysis

The SPSS 21 (version 21.0, Chicago, IL, USA) was used to perform the statistical analysis. The correlations between age, gender, dominant side, fasting blood sugar level, BMI, smoking, drinking, and the graft bone resorption rate were tested by the Pearson test (continuous variables such as age,

fasting blood sugar level, and BMI) or the Spearman test (categorical variables such as gender, dominant side, smoking, and drinking). And if there was any significant correlation between each of the factors and the graft resorption, the further regression analysis would be considered.  $P < 0.05$  was considered a significant statistical difference.

## Results

### General Results

From July 2016 to August 2018, a total of 64 patients diagnosed as anterior shoulder instability were surgically treated in our department, of whom 27 patients underwent arthroscopic autologous scapular spine bone graft for recurrent shoulder instability and were qualified and enrolled in this study. All 27 patients were well followed-up. The mean follow-up time was 29.3 months (range, 25–39 months), during which time no severe complications such as infection, neurovascular injury, or re-dislocation were observed. The bone graft healed in all cases, the mean healing time was  $2.6 \pm 0.5$  months (range, 2–3 months) (Fig. 2).

### Functional Outcome

At the last follow-up, the mean Constant–Murley score was  $89.74 \pm 3.71$ , which was significantly higher than that of preoperation ( $68.26 \pm 8.31$ ,  $P < 0.05$ ), the mean Disabilities of Arm, Shoulder, and Hand (DASH) score was  $9.77 \pm 5.31$ , which was significantly lower than that of preoperation ( $35.34 \pm 7.13$ ,  $P < 0.05$ ), the mean visual analogue score (VAS) was  $0.74 \pm 0.64$ , which was significantly lower than that of preoperation ( $4.72 \pm 3.81$ ,  $P < 0.05$ ), and the apprehension test was all negative at final follow-up.

### Radiological Outcome

All 27 patients were subject to 3D CT scans at postoperative 1 year. All cases achieved bone union at postoperative 1 year and none of them had shown arthritic changes according to radiological results. The percentage of glenoid bone loss at preoperation was  $12.57\% \pm 1.41\%$ , the percentage of the glenoid bone loss at postoperative 1 week was  $3.70\% \pm$

$1.25\%$ , and the percentage of the glenoid bone loss at postoperative 1 year was  $5.40\% \pm 1.39\%$ . The mean graft resorption rate at postoperative 1 year was  $19.4\% \pm 7.5\%$ .

### Analysis

#### Age

The mean age at the time of surgery was  $30.8 \pm 9.4$  years (range, 19–50 years). The correlation between age and graft resorption rate was tested by the Pearson test and no significant correlation was observed ( $P = 0.167$ ).

#### Gender

There were 20 males and seven females enrolled in the study. The correlation between gender and graft resorption rate was tested by the Spearman test and no significant correlation was observed ( $P = 0.569$ ).

#### Dominant Side

There were 17 patients that underwent surgery of the dominant shoulder and 10 patients underwent surgery of the non-dominant shoulder. The correlation between dominant side and graft resorption rate was tested by the Spearman test and no significant correlation was observed ( $P = 0.770$ ).

#### Fasting Blood Sugar Level

None of the 27 patients developed diabetes. The mean fasting blood sugar level at the time of surgery was  $4.78 \pm 0.42$  mmol/L. The correlation between fasting blood sugar level and graft resorption rate was tested by the Pearson test and no significant correlation was observed ( $P = 0.706$ ).

#### Body Mass Index

The mean Body Mass Index (BMI) at the time of surgery was  $23.70 \pm 4.70$ . According to BMI classification, one patient was thin, 18 patients were normal, seven patients were overweight, and one patient was fat. The correlation between BMI and graft resorption rate was tested by the Pearson test and no significant correlation was observed ( $P = 0.825$ ).



**Fig. 2** The scapular spine bone graft healed at the anteroinferiorglenoid. (A) The enface view indicated well union between glenoid and the scapular spine bone graft. (B) The lateral view indicated the scapular spine bone graft was flush with the glenoid surface.

### Smoking

Of all the patients enrolled, five were considered as “smoking” and 22 were considered as “non-smoking.” The correlation between smoking and graft resorption rate was tested by the Spearman test and no significant correlation was observed ( $P = 0.716$ ).

### Drinking

Of all the patients enrolled, four were considered as “drinking” and 23 were considered as “non-drinking.” The correlation between drinking and graft resorption rate was tested by the Spearman test and no significant correlation was observed ( $P = 0.595$ ).

On the whole, the Pearson test and the Spearman test showed no significant correlation between age, gender, dominant side, fasting blood sugar level, BMI, smoking, drinking, and graft resorption rate (Table 1).

## Discussion

In the treatment of shoulder anterior instability, bone graft resorption is the most common cause of failure. Scapular spine bone graft, as a novel technique, has been proven to be safe and effective, while it is still in the risk of graft resorption. Currently, no direct evidence has been found to fully explain the most essential cause of graft resorption. The results indicated no significant correlation between the bone graft resorption and the general factors such as age, gender, dominant side, BMI, fasting blood glucose level, smoking, and drinking. Generally, the factors aforementioned are thought to affect the blood supply, activity of growth factor, the ability of tissue repair, the ability of osteogenesis, the activity intensity of the shoulder, etc. Theoretically, they have a crucial effect on the resorption of the bone graft. However, the results support the opposite. It seems to indicate the bone graft resorption is more contributed to the local biomechanical environment (Wolff's law) around the glenohumeral joint other than the general conditions.

Coracoid bone graft (Latarjet procedure) and Iliac bone graft (Eden-Hybinnette procedure) both would go through resorption in certain degrees just like scapular spine bone graft. Reports showed graft resorption would occur in approximately 60% of Latarjet cases<sup>11</sup>. Two factors have been considered as the reason of graft resorption in Latarjet process, one is biomechanical environment (Wolff's law), the other is local blood supply. Under the effect of the

biomechanical force, the coracoid bone graft tends to be analogous to glenoid, which in the end develops into a “pear-shape.” This phenomenon was also observed in the process of scapular spine bone grafting. Young Moon Kee has indicated the graft resorption mainly occurs in the superior part of the graft just outside the glenoid circle, and the resorption process is a result of biomechanical stimulation, thus also known as “remodeling”.<sup>11</sup> The remodeling process is usually completed at 8 months postoperation and is not going to progress as time goes on. For the biomechanical environment on the interface of bone graft and the glenoid, scapular spine bone graft technique is quite distinguished from the Latarjet procedure. Flexible fixation by the suture is adopted in scapular spine bone graft other than the rigid fixation (screws), thus it allows the graft to self-adjust to prevent overhang against the glenoid surface and to ultimately keep in flush position with it. Furthermore, flexible fixation allows compression adjustment in certain degrees (due to suture extensibility) preventing excessive interface compression. Bülent Alp Nazmi has indicated strong correlation between interface compression with graft resorption, especially that the excessive compression between the glenoid and the bone graft would lead to extensive graft resorption and this result is probably due to reduced blood supply.<sup>10</sup> Meanwhile the flexible fixation by the suture reduces the stress shielding, which allows more compression to transfer to the interface and improve the union of bone graft. Generally, the blood supply for inner part of the coracoid graft is much better than in the outer part due to direct contact with the decorticated glenoid. And blood supply decreased from the conjoint tendon right superior to the proximal part of the bone graft, causing the blood supply of the superior part of bone graft is poorer than that of inferior part.<sup>13, 14</sup> Eden-Hybinnette technique (iliac bone grafting) is usually considered as a revision when primary Latarjet procedure failed.<sup>15</sup> The fixation of iliac bone graft usually involves screw, endobutton, suture, and no implant (J-shape grafting). Moroder has referred, in their study, extensive and in some cases subtotal graft resorption occur in iliac bone grafting<sup>16</sup>. They attribute the extensive bone graft resorption to graft remodeling due to Wolff's law. It seems that glenoid grafting is likely to create a non-anatomic state and substantial graft resorption is working as a remodelling process. On one hand, the scapular spine bone graft is analogous to scapular bone just like coracoid, while on the other hand it's also a free bone graft

**TABLE 1 Correlation tests between age, gender, dominant side, fasting blood sugar level, BMI, smoking and drinking\***

General factors	Cases	Age(y) (Mean ± S.D)	Gender (M/F)	Dominant side (Yes/No)	Fasting blood sugar level (mmol/L) (Mean ± S.D)	BMI (Body Mass Index) (Mean ± S.D)	Smoking (Yes/No)	Drinking (Yes/No)
	27	30.8 ± 9.4	20/7	17/10	4.78 ± 0.42	23.70 ± 4.70	5/22	4/23
P-value	-	0.167	0.595	0.770	0.706	0.825	0.716	0.595

S.D., standard deviation.; \* Indicates significant difference. The correlation between the age, fasting blood sugar level, BMI and graft resorption was tested by the Pearson test; the correlation between gender, dominant side, smoking and drinking was tested by the Spearman test)

(unlike the coracoid bone graft in its attachment to conjoint tendon) and is similar to iliac bone graft at this point. Thus, the scapular spine bone graft resorption rules differ from those of coracoid graft and iliac graft. According to the results of this study, general factors have rare influence on the scapular spine bone graft resorption and further local biomechanical studies should be considered, such as infinite analysis.

Among all the potential general factors, age is the most likely influential factor for graft resorption ( $P = 0.167$ ). Age is agreed by most as the influential factor for fracture healing, with which the graft incorporation shares the similar physiological changes. However, in our results, no significant correlation was found. There are two reasons may explain this result. On the one hand, the patients included are relatively few, and the significant correlation could not be found. On the other hand, the mean age of patients in this study is young (30.8 years), which means that the healing ability of all the patients is comparatively high and thus it's hard to identify any significant difference between each individual.

Yet as the subjects' age increase, the significant correlation between age and bone graft resorption may be found out.

### Limitations

There are some limitations of this study: (i) the sample size is relatively small; (ii) there may be other general factors that would affect the graft resorption, but we did not include these in the study; (iii) this is a retrospective study, the grouping is unbalanced thus bias may exist. Further random controlled studies are needed to more accurately explore the correlation.

### Conclusion

Age, gender, dominant side, fasting blood sugar level, BMI, smoking, or drinking are not significantly correlated with graft resorption after the arthroscopic autologous scapular spine bone graft for recurrent shoulder instability. Similar to Latarjet and Eden-Hybinette procedure, the local biomechanical environment may be the essential influential factor for graft resorption and requires further analysis.

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