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## Original Article

## Clinical outcomes of an all-arthroscopic glenoid reconstruction using iliac crest bone graft with a double cannulated screw fixation technique



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## ABSTRACT

**Introduction:** Significant glenoid bone loss contributes to recurrent anterior shoulder instability. Reconstruction using an iliac crest bone graft provides an anatomic restoration of the glenohumeral arc. We present a case series of an all-arthroscopic glenoid bone reconstruction using iliac crest bone graft (ICBG) with a double cannulated screw fixation technique.

**Materials and methods:** This is a retrospective study from 2012 to 2017. Patient selection was based on Instability Severity Index Score (ISIS) of greater than 3 points and the presence of glenoid bone defect of more than 20% surface area. The ICBG was harvested from the ipsilateral hip and delivered arthroscopically to the deficient glenoid. The bone graft was then fixed with two cannulated screws. All patients were evaluated at 0, 6, 12 and 24 months for range of motion, isometric strength, pain score, and functional outcome scores: Constant-Murley Score (CMSO), Oxford Shoulder Score (OSS), and UCLA Shoulder Score.

**Results:** 7 patients (6 males, 1 female) with the mean age of 40.2 years and mean glenoid bone loss of 41.8% were included. At 24 months, the mean active flexion improved from 119 to 143° ( $p = 0.128$ ) and active abduction improved from 112 to 138° ( $p = 0.063$ ). Isometric strength increased from 14.7 to 17.6lbs ( $p = 0.345$ ). All functional scores showed significant improvement ( $p < 0.05$ ), where CMSO increased from 66.9 to 81.4; OSS 17.4 to 31.4, and UCLA score 23.5 to 32.1. Pain score improved from 4 to 0.5. Bone graft incorporation was confirmed for all the cases and none had recurrent instability. One patient required screw removal for screw cutout.

**Conclusion:** Our mid-term results for an all-arthroscopic glenoid reconstruction using ICBG demonstrated good clinical result with minimal complications.

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## Introduction

Significant glenoid bone loss contributes to recurrent anterior shoulder instability. It has been reported that up to 22% who suffered from initial traumatic shoulder dislocation had some degree of bone loss due to fracture of the glenoid rim.<sup>1–3</sup> The failure rate for arthroscopic Bankart repair has been shown to significantly increase from 4% to 67% in those with significant glenoid bone loss.<sup>4</sup>

An attritional pattern of bone loss after a period of time following trauma has also been described.<sup>5</sup>

The most common location for bone defect is at the antero-inferior glenoid rim.<sup>6</sup> Significant bone loss results in the loss of native glenohumeral joint ‘concavity-compression’ and ‘buttress-type’ restraint. This affects the ability of the glenoid to resist the axial and shear force to the joint, thus contributing to recurrent dislocation.<sup>4</sup> Previous biomechanical studies has suggested that 20% is the critical percentage bone loss of the glenoid surface area that can result in significant instability.<sup>7</sup> In such cases, anatomic reconstruction of the glenoid rim is necessary. This can be either as a primary reconstructive procedure, or as a secondary procedure in

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those who had a previous failed soft tissue stabilization procedure.

In recent years, the Latarjet procedure, which involves the transfer of the coracoid process and its attachment to restore the deficient anterior glenoid has been deemed the gold standard.<sup>8,9</sup> While early outcome has been encouraging, the Latarjet procedure is a non-anatomical solution that is technically difficult to perform, violates the subscapularis musculotendinous unit, and is associated with high incidence of neurovascular injury and early glenohumeral arthropathy.<sup>10,11</sup> Another popular option is the use of a bone block procedure to restore the bony buttress of the glenohumeral arc to prevent recurrent instability. The concept of glenoid bone augmentation was first described by Eden-Hybinette in 1918 where a tibial bone autograft was used as mechanical barrier to extend the anterior glenoid rim.<sup>12</sup> The iliac crest bone graft subsequently replaced the tibial graft due to its easier access and lesser donor site morbidity. Open iliac crest bone grafting for glenoid insufficiency is a reliable technique showing satisfactory outcome and low recurrence rate. Scheibel et al. introduced an open technique for autogenous bone grafting using ICBG via a subscapularis tenotomy approach showing good clinical results.<sup>13</sup> Likewise, Warner et al. reported his case series for 11 patients who underwent open glenoid reconstruction where none of them had recurrence after 33 months follow up, and all had confirmation of bone graft incorporation on CT scan 4–6 months post surgery.<sup>14</sup>

With the advancement of arthroscopic techniques and instruments, an all-arthroscopic bone block technique is now routinely being performed.<sup>15–17</sup> In 2008, Taverna et al. described his arthroscopic approach for an extracapsular iliac crest bone grafting on a cadaveric model.<sup>15</sup> In 2012, Anderl et al. presented a case report for an all-arthroscopic implant-free technique using a more anatomical J-shaped graft, for which the patient achieved a near full range of motion after 1 year.<sup>16</sup> In 2014, Kraus et al. published the first case series of 15 patients who undergone an all-arthroscopic approach ICBG fixation using biocompression screws showing good to excellent early clinical results.<sup>17</sup> Most recently in 2016, Boehm et al. presented their case series of 15 patients who underwent the same procedure, detailing their technique of securing the bone graft using 2 bio-compression screws combined with capsulolabral repair using 2 knotless suture anchors.<sup>18</sup>

The aim of this study was to analyze the clinical and radiological results for an all-arthroscopic glenoid reconstruction using the double cannulated screw technique for bone graft fixation performed in our institution.

## Materials and Methods

Between January 2012 to January 2017, 7 patients had undergone arthroscopic glenoid bone reconstruction using iliac crest bone graft for clinically significant glenoid deficiency. Patient selection was based on the Instability Severity Index Score (ISIS) of greater than 3 points and the presence of a glenoid bone defect surface area of more than 20% using the 'Circle of Best Fit' method on Computed Tomography (CT) or Magnetic Resonance (MR) imaging (Fig. 1a and b). Patients with voluntary and multidirectional shoulder instability, and those with glenoid fracture without bone losses were excluded. A single surgeon (the senior author) with more than 15 years of shoulder arthroscopy experience performed the surgery. The minimum follow up period was 24 months.

### Study population

Our cohort of 7 patients consists of 6 males (86%) and 1 female (14%) patient. The mean age at the time of surgery was 40.2 years (range, 25–74 years). The dominant arm was involved in 6 patients (86%). Of the 7 patients, 3 had history of epilepsy which contributed

to recurrent dislocation (43%) and 4 had prior soft tissue stabilization surgery i.e. Bankart repair (57%).

The presence of anteroinferior glenoid deficiency was confirmed based on advanced imaging. For those with history of epilepsy, surgery was only offered after the condition was deemed well controlled by their physician for at least 3 months. All the patients in the study had no other major co-existing shoulder pathology such as rotator cuff deficiency. The mean percentage of glenoid bone loss was 41.8% (range, 25.5–53.8%) based on pre-operative CT or MRI (Table 1).

### Surgical technique

#### Step 1: Positioning and portals

- Under general anesthesia, the patient is placed in a beach chair position at 45° inclination with the shoulder adducted. A sand bag is placed on the ipsilateral hip to facilitate concurrent iliac bone graft harvest. The shoulder and hip were prepared in a sterile technique and covered with surgical drapes (Fig. 2a).
- The standard posterior, antero-superior, and antero-inferior arthroscopic portals were established. An additional antero-lateral post is made as a viewing portal for the procedure (Fig. 2b).

#### Step 2: Preparation of the glenoid rim

- The labrum is carefully detached using a liberator and any frayed tissue is debrided with a shaver.
- The camera is then shifted to the antero-superior portal, and a calibrated probe is inserted via the posterior portal to measure the distance between the anterior and posterior rims to the bare-spot. The difference between the both, divided by the diameter of the rim (two times the posterior distance) is the estimated percentage of bone loss. With that, the desired size of the bone block can be determined.
- The anterior glenoid rim is decorticated and flattened with the shaver to create a flat bleeding bone surface for accommodation of the graft. The rotator interval is then debrided till the conjoint tendon is clearly seen. Next, the antero-inferior portal is widened to 2 cm to prepare for delivery of the bone block.

#### Step 3: Iliac bone graft harvest

- The tricortical bone graft is harvested from the ipsilateral hip. This can be performed concurrently with the arthroscopic procedure. A 3 cm skin incision is made over the anterior superior iliac crest (ASIS) and dissected down to the outer cortex of the bone.
- The iliac crest bone is marked and sawed into a 2 x 1 x 1 cm bone block. The bone block is cut to fit the sloping vault of the anterior glenoid, such that inner table of the iliac crest conforms to the articulating face of the glenoid. This is fashioned as a J-shaped block to match the glenoid slope (Fig. 3a).
- Two parallel Kirschner wires are drilled to mark the planned position of the screws and removed after (Fig. 3b and c).

#### Step 4: Securing the bone graft

- A double-loaded suture anchor (Gryphon Healix BR System, Mitek Depuy Synthes, MA, USA) is placed at the 5 o'clock



**Fig. 1.** A) Computed tomography 3D reconstruction of the scapula showing the glenoid bone defect. B) MRI sagittal cut of a glenoid bone defect measured by a 'Circle of Best Fit' method to determine the degree of bone loss.

**Table 1**  
Demographic characteristics of the study population.

Characteristic	Value
Number of Shoulders	7
Age	40 (25–74)
Gender	
<b>Male</b>	6
<b>Female</b>	1
Percentage glenoid bone loss	41.8% (25.5–53.8)
Dominant shoulder	
<b>Dominant</b>	6
<b>Non-Dominant</b>	1
Contributing Factors	
<b>History of Epilepsy</b>	3
<b>Previous Bankart repair</b>	4
Complications	
<b>Superior Screw Cut out</b>	1
<b>Recurrent Dislocation</b>	0

anteroinferior position of the deficient glenoid rim, and 1 pair of suture is parked in the antero-superior portal. (Fig. 4a)

- An inferior capsular pouch is first created, by tenting up the inferior capsule and anterior inferior glenohumeral ligament (IGHL).
- The orientation of the bone block is determined, where the convex outer table is matched to the glenoid slope, and the inner concave cancellous portion is matched to the decorticated glenoid surface.
- The bone graft is carefully delivered in a horizontal orientation through the antero-inferior portal. After it clears over the subscapularis tendon, the block is kept upright using a grasper from the antero-superior portal.
- An obturator from the antero-inferior portal is used to push the bone block to position (Fig. 4b). A 1.6 mm Kirschner wire is placed in the previously created drill hole to secure the position of the bone graft. The position of the wire is in the upper half of the block. Next, a 3.5 mm cannulated headless compression screw (Depuy Synthes, PA, USA) is introduced over the wire and carefully threaded in to anchor the bone block onto the glenoid

rim (Fig. 4c). The screw will thus rest at the 3 o'clock position of the glenoid (right shoulder).

- A second 3.5 mm cannulated screw is placed inferior to it to provide additional support for the bone graft. Once the graft is fixed, the initial sutures that created the inferior pouch are then retrieved. The sutures were used to plicate any patulous anterior capsule and inferior glenohumeral ligament to provide a soft-tissue augment to the bony glenoid reconstruction (Fig. 4d). The sutures were not incorporated or tied to the bone graft.

### Rehabilitation

Post-operatively, all the patients were placed in an arm sling. Gentle pendulum exercises were initiated after surgery, followed by passive range of motion at week 2 and active assisted range of motion from week 4. From week 6 onwards, they were allowed active range of motion and gradual strengthening exercises.

### Outcome assessment

#### Clinical assessment

All patients were examined pre-operatively and post-operatively within 3 months, 6 months, 12 months, and 24 months. The surgeon assistant (not the performing surgeon) evaluates the patient. At the final follow up, all patients undergo a complete physical examination where range of motion for forward flexion and abduction, and isometric strength were measured and compared to the contralateral shoulder. The examiner also looked out for signs of persistent instability and a positive apprehension test. Other functional assessment includes the Constant-Murley Shoulder Outcome (CMSO) score, University of California (UCLA) Shoulder score, and Oxford Shoulder Score (OSS). Pain score was also measured on a visual analogue scale (VAS). These were objectively assessed and recorded by our Orthopedic Diagnostic Center (ODC).

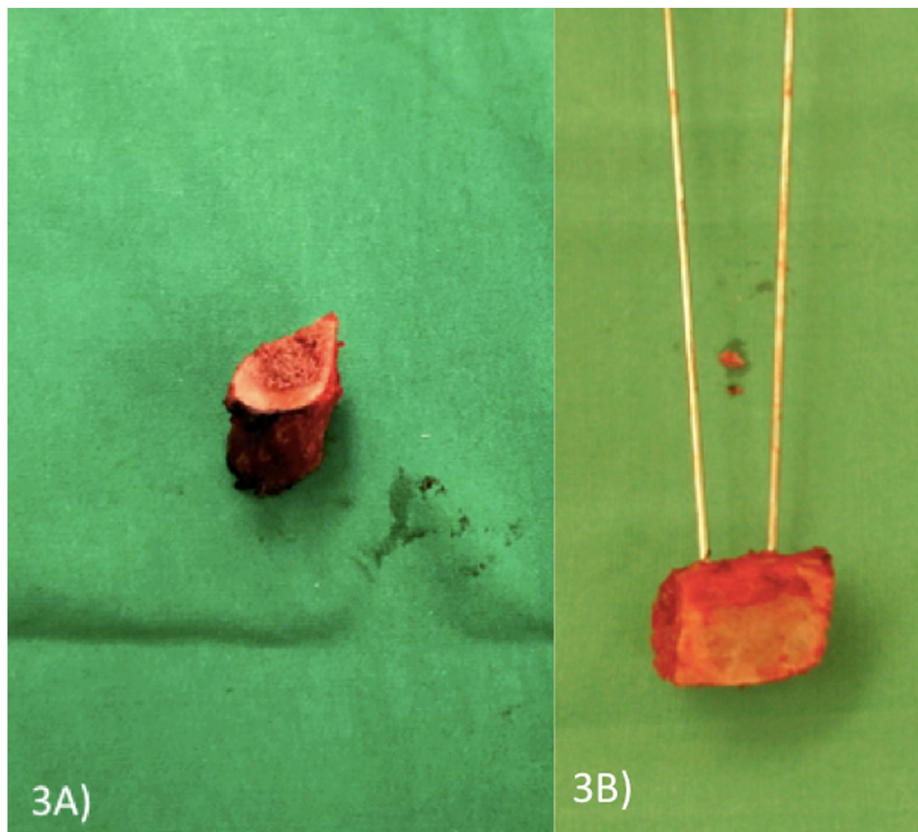
#### Radiographic assessment

Antero-posterior, lateral, and axillary view radiographs of the





**Fig. 2.** A) The patient is positioned in a 45° beach chair position with the shoulder adducted. B) The standard 3 arthroscopic ports, i.e. posterior (P), antero-superior (AS) and antero-inferior ports (AI) were established. An additional antero-lateral (AL) portal was made as an extra viewing portal. The antero-inferior (AI) port is widened to facilitate delivery of bone block.

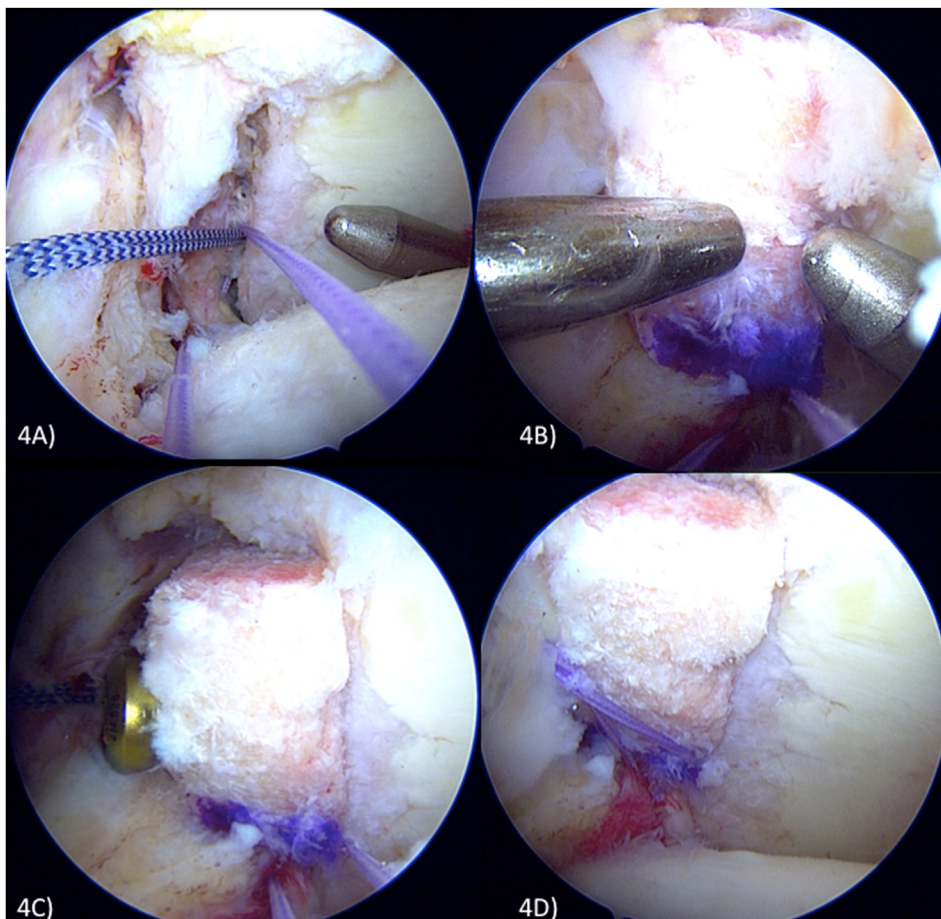


**Fig. 3.** A) A tricortical iliac crest bone block was harvested and fashioned into a J-shape graft. B) The parallel wires marked the planned position of the screws.

shoulder were performed at 3, 6, 9 and 12 months to determine the graft and implant position. Any signs of graft migration, screw cut-out, and presence of glenohumeral arthritis were recorded. These were evaluated by our musculoskeletal radiologist.

#### Statistical analysis

Independent sample t-test was used for parametric continuous variables, and Mann-Whitney-Wilcoxon test was used for non-parametric continuous variable. The level of significance is with P values of less than 0.05. Data analysis was performed using the SPSS



**Fig. 4.** A) A double-loaded suture anchor (Gryphon, Mitek) is placed at the anteroinferior glenoid rim., B) The iliac crest bone block is delivered to the inferior glenoid. The obturator probe is used to position the graft and hold it in place, C) A 1.6 mm Kirschner wire is used to secure the position of the graft, followed by a 3.5 mm cannulated headless compression screw to fix the bone block to the glenoid bone. A second screw is to be inserted inferior to the first. D) The remaining suture anchor is knotted to recreate the capsulolabral soft tissue bumper. The end result showed a secure bone block with satisfactory compression.

Software Package Version 23 (IBM Inc, USA).

**Results**

*Clinical outcome*

The mean follow up duration was 24 months (range 18–25 months). At the final follow up, the mean active range of flexion improved from 119 to 143° (p 0.128) and mean active abduction improved from 112 to 138° (p 0.063). The mean isometric muscle strength increased from 14.71 to 17.57lbs (p 0.345) (Table 2, Fig. 5).

There were no reports of recurrent instability.

The Constant-Murley Shoulder Outcome (CMSO) score showed an increase from 66.85 to 81.35 (p 0.05); the Oxford Shoulder Score (OSS) from 17.42 to 31.42 (p 0.016); and the UCLA Shoulder Score from 23.57 to 32.1 (p 0.017). All parameters showed statistically significant improvement of p < 0.05. Pain score (VAS) also improved from 4 to 0.5 (p 0.08) (Table 2, Fig. 6).

*Radiological outcome*

All patients showed satisfactory bone graft incorporation on the

**Table 2**  
Range of Motion, Isometric Strength and Functional Score before and after surgery (2 years).

Range of Motion (degrees)	Score		P value
	Pre op	2 years	
<b>Forward Flexion</b>	119.14 (10–156)	143 (103–168)	0.128
<b>Abduction</b>	112 (10–160)	137.71 (117–160)	0.063
Isometric Strength (lbs)	14.71 (0–27)	17.57 (9–23)	0.345
Scoring System			
<b>Constant-Murley Shoulder Outcome Score (CMSO)</b>	66.85 (9.5–93)	81.35 (64.5–92)	0.05*
<b>Oxford Shoulder Score (OSS)</b>	17.42 (12–32)	31.42 (23–42)	0.016*
<b>UCLA Score</b>	23.57 (5–30)	32.14 (27–38)	0.017*
<b>Visual Analogue Scale (VAS)</b>	4 (0–8)	0.5 (0–2)	0.08

\*statistical significant (p < 0.05).

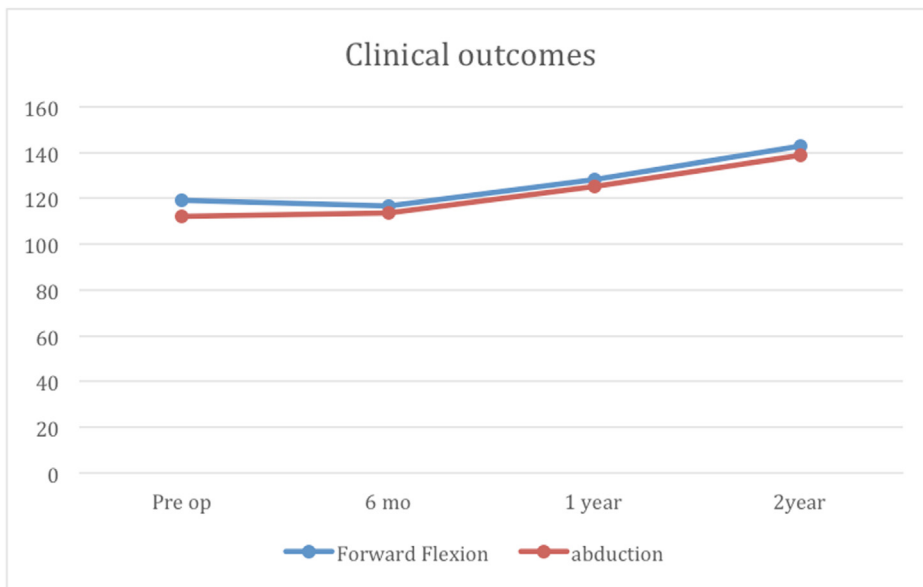


Fig. 5. Shoulder range of motion at pre-operation, 6 months, 1 year and 2 years post arthroscopic glenoid reconstruction.

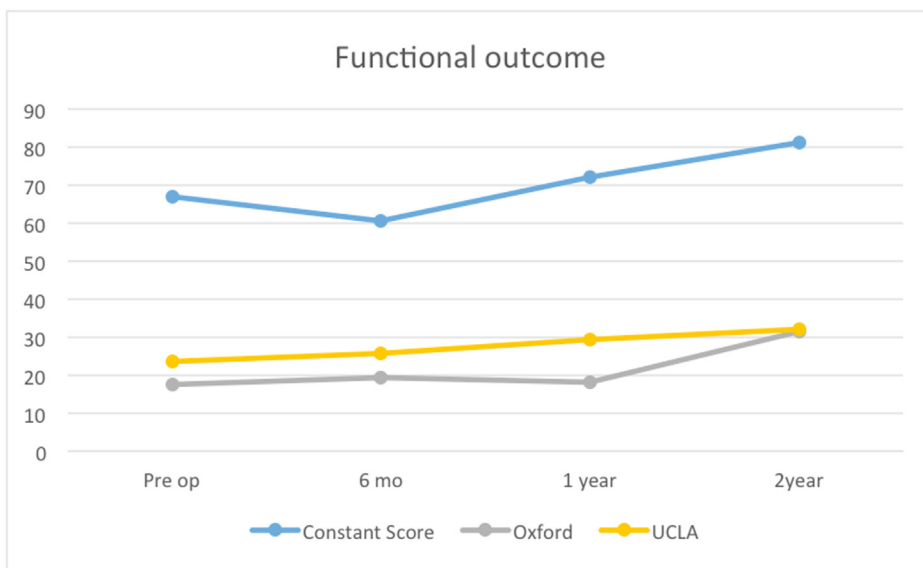


Fig. 6. Functional outcome scores at pre-operation, 6 months, 1 year and 2 years post arthroscopic glenoid reconstruction.

3, 6, 9 and 12 months radiograph (Fig. 7a and b). One patient complained of persistent anterior shoulder pain after surgery, with axillary view radiograph revealing cutout of the superior screw (Fig. 7c). This patient underwent a screw removal procedure at 8 months post-surgery with complete resolution of pain. There were no signs of graft migration, screw breakage, or significant glenohumeral arthritis in all the patients.

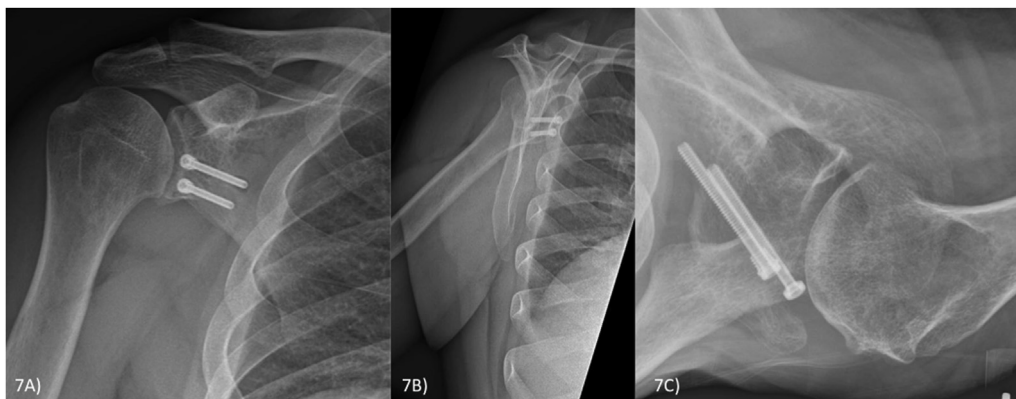
**Discussion**

The goal in the treatment of glenoid deficiency is to reestablish the bony buttress of the glenoid rim, which is pivotal in providing resistance to the axial and shear force in the glenohumeral joint to prevent recurrent instability. The Edin-Hybinette bone block procedure is a reliable technique that is used to restore glenoid rim deficiency. An iliac crest bone graft has the biomechanical merit in

providing an anatomic restoration of the glenohumeral arc.<sup>19</sup> A well-contoured iliac crest bone block should have the concavity of the iliac bone matching the slope of glenoid rim to provide a smooth gliding surface for the humeral head.<sup>20</sup>

This technique of iliac crest bone grafting is an all arthroscopic technique that replaces the conventional open approach. The most important advantage is that it does not violate the subscapularis musculotendinous unit. This technique neither takes down nor goes through the subscapularis muscle, unlike in the open approach or Latarjet procedure. This is important in maintaining the stability of the shoulder and to facilitate early post-operative rehabilitation.<sup>21</sup> Another important advantage is that an all arthroscopic approach offers the surgeon more a global view of the shoulder joint. Often at times, there can be more than one pathology and this can be addressed concurrently. The other advantages include lesser soft tissue dissection, lesser post-operative





**Fig. 7.** A & B) Standard AP and lateral view radiograph of the shoulder joint at 6 months post-operation showing satisfactory position of the implant and bone graft. C) Axillary view radiograph showing superior screw cut out. This patient required a screw removal procedure at 8 months post operation.

pain, reduced risk of infection, and earlier return to function.<sup>22</sup>

Several arthroscopic techniques using iliac crest bone graft has been described in literature. Scheibel et al. described one of the first arthroscopic techniques for iliac bone grafting using a bio-compression screw for interfragmentary compression combined with capsulolabral repair using suture anchors.<sup>21</sup> Kalogrianitis introduced a knotless fixation technique using an adjustable-length loop cortical suspensory fixation device, or also known as the TightRope-RT (Arthrex) which eliminates the use of screws and their potential problems.<sup>23</sup> For our case series, we used two metallic cannulated screws (Depuy Synthes, PA, USA) for graft fixation combined with a double loaded suture anchor (Gryphon, Mitek, J&J) for capsulolabral augmentation.

The mean glenoid surface area loss in our series was 41.8%, meeting the indication for clinically significant glenohumeral instability. At 2 years post-surgery, there is an improvement in the mean active forward flexion by 16.8% and active abduction by 18.8%. The major finding in this study is a significantly improved functional score and pain score. Our findings are consistent with Kraus et al. in which their series of 15 patients who underwent arthroscopic glenoid reconstruction reported a significant improvement of the mean Constant score, Western Ontario Shoulder Instability Index (WOSI), shoulder function score with no recurrent instability after a mean follow up of 20 months.<sup>17</sup> While there were no significant differences in the pre and post surgery isometric muscle strength, we believe that the sparing of the deltoid and subscapularis muscle plays a role in maintaining the strength and stability of the shoulder.

Bockmann et al. presented his clinical results for 32 patients who underwent the same procedure using two double-helix screws (metallic or bioresorbable screws). His cohort demonstrated good functional results with a recurrence rate of 9% at 42 months follow up.<sup>19</sup> Our surgical approach was similar but there were no instances of recurrent instability. However, one of our patients suffered from persistent shoulder pain that was attributed to screw cutout. We believe that some degree of graft resorption could have taken place as this was not visualized in the initial post-operative radiograph. This patient eventually required a second procedure for screw removal.

The limitation to this study is that it is a small sample size and is a retrospective review of a prospectively collected registry data. To minimize the bias, the evaluation of patient was performed by another observer. We recognize that this procedure is technically more demanding than the conventional open technique and has a steep learning curve. It is imperative to have an experienced surgical team to facilitate concurrent bone graft harvesting and for

precise placement of the bone graft and screws. The main difficulty we encountered was is in positioning of the bone graft as the graft needs to be adequately stabilized before the placement of Kirschner wire. Secondly, as we did not utilize a specialized arthroscopic instrument set, we encountered frequent interference of the surrounding soft tissue during drilling of wire and placement of screw. We also acknowledge that this procedure takes a longer operative duration than an open approach. However, the benefits of an all arthroscopic approach outweigh the morbidity of an open approach.

## Conclusion

In conclusion, our case series demonstrated good clinical results with minimal morbidity. An arthroscopic bone block procedure obviates the risks of open surgery and does not cause permanent change to the anterior shoulder anatomy unlike in a coracoid transfer procedure. This technique has a steep learning curve and we believe that further technical modification can be made to make it more feasible for an all-arthroscopic approach.

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## Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

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