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Scapular spine fracture, presentation of two cases and novel surgical treatment



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Reverse shoulder arthroplasty (RSA) becoming more and more popular with wider indications. Initial Grammont style medialized and distalized center of rotation to increase deltoid lever arm. Due to nature of this design, and 155° neck shaft angle, they have high rate of scapular notching and detensioning of internal and external rotators of shoulder. To amend those issues, lateralized glenoid and/or humerus implant, so called onlay, has been designed. Total of 42,513 RSAs have been reported in Australian Joint Registry 2022, with 15.3% increase compared to previous report. Among the 10 most common used implants, 55% of them are lateralized implants²¹ which lateralized center of rotation and increase strain of spine of scapula.⁹

Scapular spine fracture (SSF) is one of the challenges we are facing after RSA with incident of 0.8% to 11% reported in literature.^{1,5,11} With lateralized onlay implant become more popular (55% in 2021)²¹ as per Australian joint registry, our implant causes more straining of scapular spine and acromion.⁹ In fact, 5-10 mm of lateralization shown to increase scapular spine strain by an average of 25%-29% depends on where measurement was made from acromion to the spine of scapula.⁹ Therefore, most likely we will deal with more and more SSF in near future, while there is no consensus about treatment of these fractures.

SSF associated with RSA classified into 3 zones by Levy, “type I indicated involvement of a portion of the anterior and middle deltoid origin; type II, at least the entire middle deltoid origin with a portion but not all of the posterior deltoid origin; and type III, the entire middle and posterior deltoid origin”¹² (Fig. 1).

Institutional review board approval was not required for this case report.

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SSF will deteriorate RSA functional score and pain level.¹⁷ This is challenging as even surgical fixation will not necessarily restore previous function.¹⁵

Surgical fixation of Levy type III is challenging due to limited bone stock and potential osteoporosis in that age group. Even revision of implants to regain the tension of deltoid has been suggested in cases that are not amenable to fixation.⁵ The most advocated method of fixation been double plate fixation.¹⁸ The issue of this technique is, it does not address the poor bone stock and can fail in the setting of increase strain on the fracture due to RSA in place.

Author would like to report outcome of 2 uncommon cases of SSF Levy type III fractures. Author had a case of failed double-plate fixation of Levy type III spine of scapular fracture (case 1). Immediately after failure of fixation, patient denied revision surgery but after a year due to poor pain control and poor function decided to come back for treatment. Author contemplated using 3-dimensional (3D) printed model and precontour lateral clavicle locking plate in the office based on the reduced fracture segment on 3D model⁴ and augmented it with strut allograft in supraspinatus fossa and packing the space between spines of scapula to allograft with cancellous bone graft. Subsequently, author used similar technique in another case. Both of these patients consented to participate in this study.

Report of 2 cases

Case 1

An 81-year-old lady, with background history of emphysema, hypertension, sleep apnea, and osteoporosis. She had RSA (DeltaXtend Grammont style; DePuy Synthes, Raynham, MA, USA) for left grade 3 cuff arthropathy back in 2016 elsewhere. In space of 4 months post

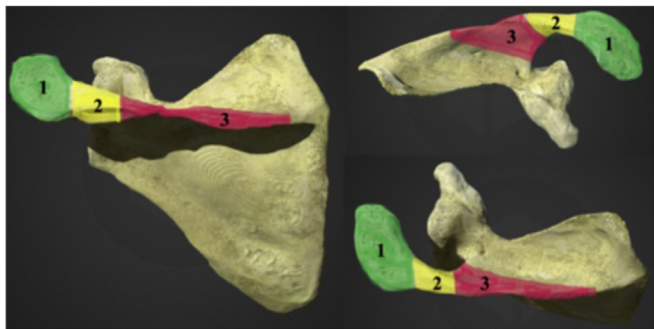


Figure 1 Levy classification of scapular spine fracture 12, 5.

index surgery, she sustained stress fracture of spine of scapula, treated conservatively. Her first presentation to author was in 2019 with a dislocated left RSA (first episode), further investigation with computed tomography (CT) scan confirmed further displacement of the previous spine of scapular fracture treated conservatively by previous surgeon. Then author performed open reduction internal fixation (ORIF) of spine of scapula with double-plate fixation technique, 2.7 locking plate to spine of scapula, and 2.4 locking plate to infraspinatus fossa 90/90 configuration (Fig. 2) (DePuy Synthes, Raynham, MA, USA) with Aptus H plate to lateral acromion fracture (Médartis). Unfortunately, they failed at 6 weeks postsurgery with the lateral part of fracture escaping fixation. She decided not to have any more surgery back then till her pain and dysfunction caused enough hassle to come back. Then author decided to use a 3D printing of her scapula (specialized image processing software, Mimics Medical Version 24, Materialise, Belgium, segmented 3D model of the scapula printed with a 0.33 mm × 0.254 mm × 0.178 mm resolution using a Fortus 250mc 3D printer, Stratasy, CA, United States).

Using the model author precontour, a lateral clavicle plate in the room (Stryker Variax Locking Plate, Stryker, Schönkirchen, Germany) to fit the contour of reduced SSF. Also planned to use a fibular strut allograft (Australian Biotechnologies Pty Ltd.), divided longitudinally in the operating room and bevelled the lateral tip to be clear of suprascapular nerve, and supports the undersurface of acromion. After reduction and holding fracture with precontour plate over the top of spine (known as posterior position),³ the fibular strut allograft was positioned in the suprascapular fossa with another small joint plate (Minifragment T 2.4 profile plate, variax Stryker, Schönkirchen, Germany) coming from infraspinatus fossa, 90/90 figure, capturing spine of scapula, acromion and compressed cancellous bone graft in the space between allograft and suprascapular border of spine of scapula which gently decoricated to encourage healing, and cancellous allograft packed in that space. At 3 months, once the fracture united (Fig. 3), author went back and changed her poly as her previous one been worn out due to chronic subluxation and notching. She has had multiple falls onto this shoulder, none cause failure of fixation. Her Visual Analog Scale (VAS) pain score at 11 months was 0-1/10 but her shoulder function improved from 30 FF and Abd, ER to 0 to FF to 50, abd to 50, and ER to 20. The small acromial segment failed after initial double-fixation surgery and author did not chase revision on that small segment in the last operation. At 20 months postrevision of fixation, she represented for her contralateral shoulder arthroplasty; her new CT scan then was reassuring of stable fixation and union.

Case 2

A 63-year-old lady, background history of rheumatoid arthritis, hypertension, diffuse idiopathic skeletal hyperostosis, and transforaminal lumbar interbody fusion surgery. Fifteen years of pain and

difficulty with both shoulders and meta os acromiale Acromiale bilaterally. While she was on the waiting list of another public hospital, she had a fall and sustained spine of scapular fracture of her left shoulder as well which causes increasing pain and further deterioration of her function. Her VAS was 9/10 and range FF to 90, ER to 20, IR to IC, and Abd to 80. The author arranged 3D print of her scapula. A lateral clavicle plate (Variax Stryker, Schönkirchen, Germany) contoured to match the 3D model in the office (Fig. 4). In operating room, pre-contour plate was used to reduce spine of scapula. Fibular strut allograft cut and shaped to fit superior to spine of scapula, paying attention to protect suprascapular nerve. The space between native superior spine of scapula and allograft pack with cancellous bone. Then allograft fixed with a mini-fragment T2.4 plate to inferior aspect of spine of scapula (variAx Stryker, Schönkirchen, Germany) to compress cancellous graft between spine and allograft. Then proceed with standard deltopectoral, subscapularis on approach and performed, and Zimmer comprehensive RSA.

X-ray 2.5 months postsurgery showed satisfactory healing; CT scan at 11 months confirmed spine of scapular union and incorporation of the allograft (Fig. 5). Her pain subsided to 0/10 and range significantly improved to FF to 140, abd to 130, ER to 40, and IR to L5. Author noticed Os Acromiale component of fixation escaped construct at the 2.5 months post op X-ray given that it did not change her function or her pain level, left alone. She has had another X-ray 20 months post index surgery, confirming stable fixation and union of fracture.

Discussion

Author's technique offers a solution to fix osteoporotic/poor bone stock spine of scapular fracture. Adding strut graft increases rigidity and strength of the construct in addition to providing a contained space to pack cancellous bone graft, while avoid harvesting cortical iliac crest bone graft and its associated potential morbidities. This technique can be used in primary and revision setting in cases of failed open reduction internal fixation with conventional methods. Precontouring the plate (Charilaou⁴ technique) in the office saved time in operating room and facilitate reduction of the fracture in to the plate (Fig. 4).

Both of the patient achieved radiological union around 3 months after index operation and CT scan confirmed graft incorporation. VAS score changes in case 1 from 9 to 0-1 and in second case from 9 to 0.

Poor functional outcome after SSF has been reported despite of method of treatment^{15,20} with forward flexion (95°, range 30°-110°) and abduction (76°, range 30°-180°) affected the most. However, these findings are generally based on limited number of cases and poor-quality studies due to the rare nature of this type of fracture. Wahlquist¹⁹ reported 5 surgically managed cases of spine of scapula. In their series, forward elevation and pain improved with surgical fixation, but general Neer outcome score of 62 consistent with unsatisfactory outcome. The only reported revision case of failed spine of scapular fracture was from their study,¹⁹ reporting one of the 5 ORIF cases failed to unite and underwent revision surgery; however, they did not describe the technique they used for revision surgery and only mentioned that fixation failed at scapular spine rather than acromion. Reported poor outcome in the literature is in line with author's first case findings. While her pain score improved significantly, she was not worried too much about her poor range of motion. She eventually had RSA on her contralateral side with satisfactory outcomes. Poor outcome definitely did not present in second case with preoperative spine of scapular fracture; she improved her function and pain score and was very satisfied with outcomes.

Association between osteoporosis and poor fixation result reported by Patterson¹⁵ after reviewing 20 case-cohort reports. They concluded that the unsatisfied patients were the ones who had fracture nonunion and most likely being related to osteoporosis,

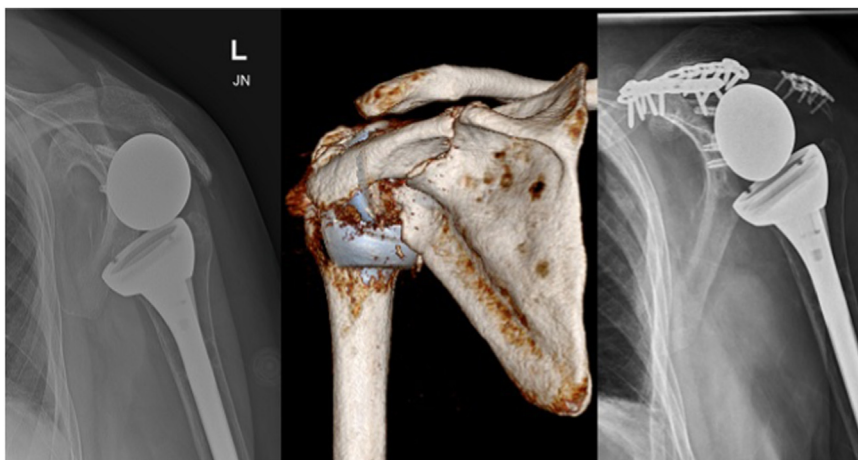


Figure 2 Left image, preop xray showing chronic spine of scapular fracture and implant dislocation, Middle image; #D CT scan of the levy III fracture, Right image, immediate postop after initial double plate fixation, NB small lateral acromion levy I segment also fixed with an Aptus hand plate (Médartis). CT, computed tomography.

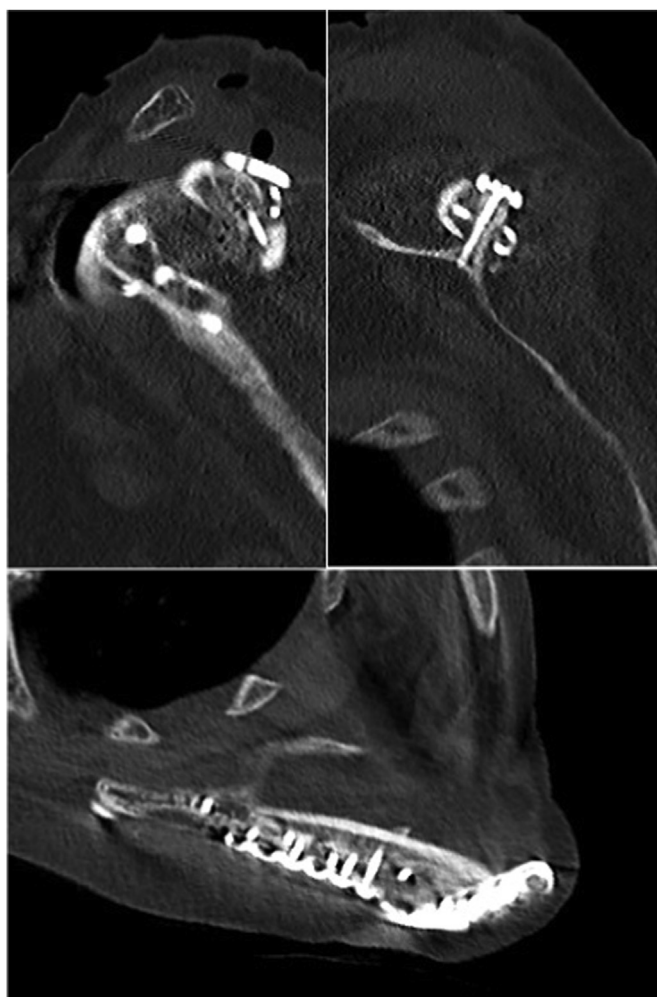


Figure 3 3 months postrevision surgery, CT scan confirmed union of the fracture. CT, computed tomography.

which limits the conventional open reduction internal fixation options. However, there were no reports of revision in their review series.

There is a debate in the literature about effect of onlay vs. Grammont style implants. Case number 1 had a Grammont style

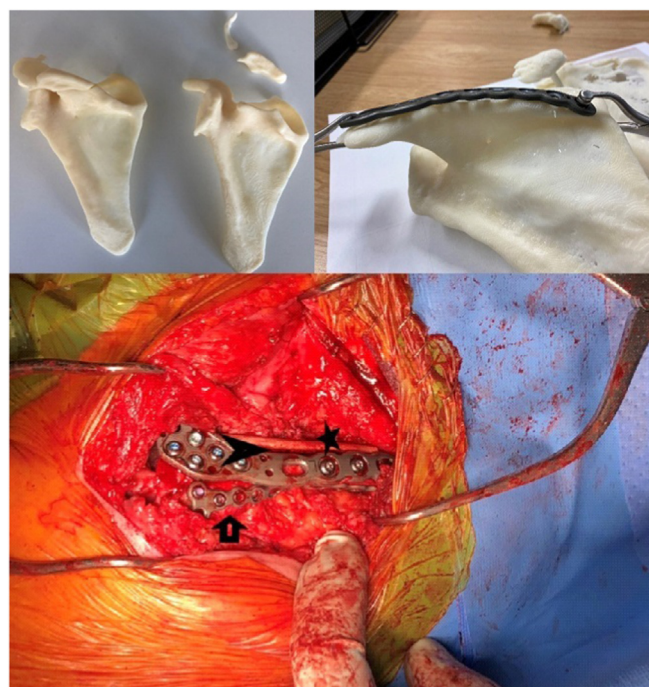


Figure 4 3D printed model with reduced spine and os acromiale. Top right: prebending Stryker variax plate in the office. Bottom picture: intraop photograph, star showing fibular strut graft, arrow head the 2.4 minifragment Stryker plate, with medial screws goes perpendicular to spine and capture allograft, triangular head: space to pack cancellous allograft before tightening minifragment plate screws.

(DeltaXtend, DePuy Synthes, Raynham, MA, USA) implant and in second case underwent an onlay type prosthesis (Comprehensive; Zimmer Biomet, Warsaw, IN, USA). Author believes in setting of using a lateralized onlay-type implant, augmenting the fixation with allograft and double-plating will withstand the extra strain on the spine of scapular, negating need to do 2-stage procedure in this rare group of patients and facilitate early rehabilitation. Also, in cases of Levy type III SSF in osteoporotic patients, minimize the risk of failure and needing revision surgery.

Haidamous⁷ study look into the effect of lateralization and distalization of onlay and inlay implants. They came with the

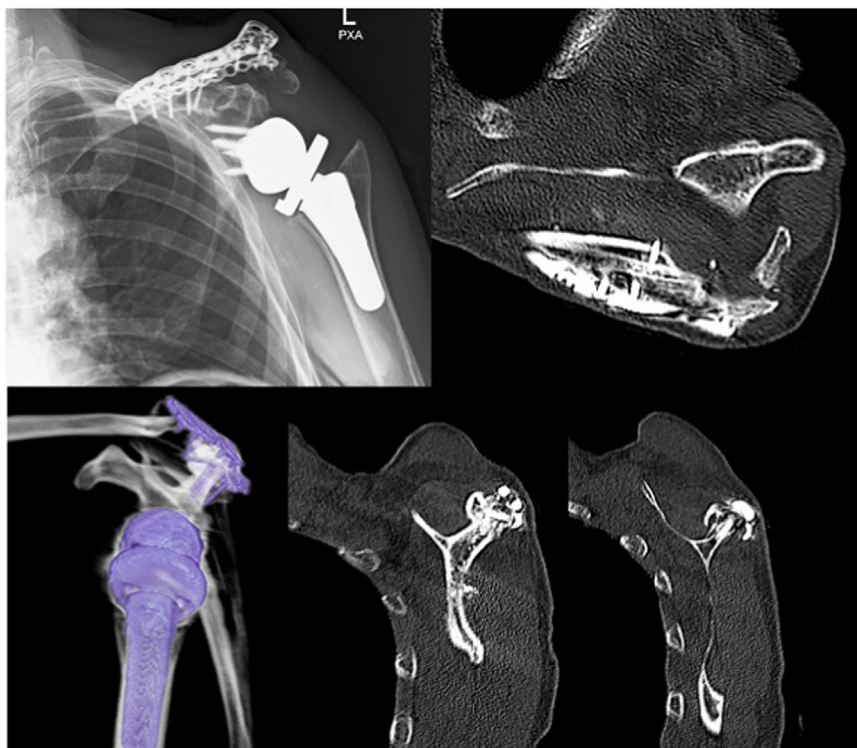


Figure 5 Top Left 3 months postsurgery, Top Right axial CT showing united allograft and spine of scapula. Bottom Left 3D CT 11 months after surgery and Middle and Right Bottom sagittal cuts showing fracture union and graft incorporation. CT, computed tomography.

conclusion that incidence of spine of scapular fracture (mainly Levy I and II, 12 and 9 of 26 cases, respectively) was 2.5 times higher with an onlay stem (11.9% vs. 4.7%, $P < .043$). In 2 other studies, Morella¹³ and Ascione¹ came to a very similar conclusion (0% of inlay vs. 7.9% of onlay and 4.3% in onlay compared to 1.3% reported literature on Grammont style, respectively). Cassidy³ did not report the type of implant been used among their pooled data of SSF. Sušiek¹⁷ reported pooled result of 11 studies reporting SSF after RSA; among the 50 cases, 2 did not report the type of implant, 21 used Grammont style RSA (mainly Delta III, Depuy Synthes, Raynham, MA, USA), and 27 lateralized implants (mainly Ascend flex; Tornier, Bloomington, MN, USA following by DJO surgical, Lewisville, TX, USA).

The fact is Levy zone III is extremely uncommon and in one of the largest series they only had 5 cases.⁷ Other authors showed that this type correlates with placement of superior screw near the spine of scapula causing stress riser,^{1,14} but even in their study just under half of fracture did not correlate with screw position which is in line with author's first case.

In Sušiek¹⁷ review, they identified 11 studies including 69 patients who had spine of scapular fracture with RSA. Nearly all of those 62 patients treated nonoperatively were limited with their shoulder function at the final follow-up and only 6 of them had bony union (although many did not have reported radiographic follow-up, so the number probably underrated).

Of 7 patients operated with double-plate fixation technique, 6 achieved union and 2 had complications, one pneumothorax and other screws loosening. Generally, they achieved better functional outcome compared to their preoperative score despite of nonoperative cases.

In Cassidy study,³ they identified 18 reported SSFs treated surgically. Ten of them Levy II and 7 Levy III. Of the Levy III cases, 5 had dual-plate fixation and other 2 single-plate fixation. In the

single-plate cases, a lateral clavicle plate¹⁰ and 1/3 tubular plate⁶ was used.

Of the 8 patients with double-plating technique, 5 had superior locking plate with caudally 1/4 tubular plate (LCP plate in one, variable angle olecranon plate in one, and lateral distal humerus plate in 3 of them). One of them had combination of 2.4 locking locking compression plate caudally and lateral clavicle plate superiorly. Other had lateral clavicle plate and Reconstruction plate augmentation perpendicular to each other. The last case had 3.5 locking plate augmented with 2.7 locking plating (both Zimmer, Warsaw, IN, USA). In Toft study,¹⁸ 2 of his 5 cases needed cancellous graft and 2 needed cancellous with bicortical iliac crest autograft combined. Four of the Levy III had cancellous bone graft, augmented with bicortical iliac crest graft, all achieved healing.

Cassidy³ concluded that double-plating has the highest chance of achieving union and biomechanically strong enough to withstand the extra strain of the acromion-spine of scapular region in setting of RSA confirmed by Katthagen⁸ biomechanical study. Among the various possible plate positions (superiorly supraspinatus fossa, spine of scapula-posterior position, and caudally-infraspinatus fossa); they³ concluded single plate has potential highest strength in posterior position and dual plating when combine posterior and caudal position which was the position of choice in author's cases.

Time to achieve union has been reported in some studies and in average is 8.5 months (2-24 months).³ Both of author's cases have been pain-free after 3-4 weeks postsurgery, and their CT scans revealed evidence of graft incorporation and healing, showing the mechanical advantage of augmenting with allograft. These findings remain the same 16 months (case 1) and 20 months (case 2) after surgery.

Author noted that small acromial segment of case 1 and Os Acromiale component of the second case failed to unite using this

technique. However, it did not change patient function and pain level. This is in line with Shin¹⁶ and Carpegiani's² findings. Both reported negligible effect of Os Acromiale in functional outcome of RSA. This particular case has bilateral meta Os Acromiale and a B3 glenoid on her contralateral side. Therefore, author suggests nonoperative treatment of the acromial parts.

Conclusion

Double-fixation of Levy type III SSF augmented with allograft and cancellous bone grafting the space between the native scapular spine and allograft, creates a rigid construct withstanding the extra strain on the lateralized RSA, also is a reliable option in revision of failed osteoporotic fracture fixation. Author does not recommend fixing Os Acromiale or lateral acromial fracture associated with Levy type III.

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