

Early Failure of an Inlay Modular Shoulder Arthroplasty for Proximal Humeral Fracture in a Retrospective Series

Keywords: Hemiarthroplasty; Failure; Shoulder; Humerus; Global Unite; Revision

Abstract

Background: Surgical reconstruction of proximal humeral fractures is difficult, and failure may occur leading to revision surgery. The development of convertible modular hemiarthroplasty has the potential to reduce the complexity of revision surgery. The aim of this study was to review the failure rate and modes of an inlay modular humeral hemiarthroplasty prosthesis used for proximal humeral fractures.

Methods: A retrospective clinical review of the medical records and X-rays was undertaken. A sawbone model was used to implant a Global FX and a Global Unite convertible hemiarthroplasty to compare differences in height and offset between the prostheses.

Results: Six patients (five females, one male) had a Global Unite hemiarthroplasty with a mean age 73.66 years. Four (66%) failed by superior migration at a mean of six months. In vitro sawbones measurement identified the humeral height of the Global Unite was approximately 3 mm higher than the Global FX (the previous model).

Conclusion: We experienced a 66% failure rate of the Global Unite by superior migration. Our previous series of Global FX had a failure rate of 23%. We postulate that the extra height of the Global Unite increases the excursion of the rotator cuff tendons, placing undue tension on the rotator cuff and tuberosity construct predisposing to early failure. We recommend that the consideration be given to downsizing the humeral head and using a smaller body where possible.

Abbreviations

AOA NJRR: Australian Orthopaedic Association National Joint Replacement Registry

Introduction

Proximal humeral fractures are common, with the majority being treated non-operatively, achieving satisfactory results [1]. However, the optimal treatment of comminuted fractures in elderly osteoporotic bone or unreconstructable high-energy fractures in younger patients remains unclear with high complication rates with attempted internal fixation [2]. Prostheses have been used to treat these unreconstructable fractures [3]. However, this operation remains technically difficult and results rely on tuberosity union and restoration of rotator function. Modular prosthesis and then fracture specific stems have been designed in an attempt to improve tuberosity healing [4,5].

Despite these refinements, failure of the hemiarthroplasty may occur leading to revision surgery. Superior migration is a common mode of failure for cuff deficient shoulders, and is also seen in failed hemiarthroplasties where the rotator cuff-tuberosity complex is deficient. Superior migration is associated with large supraspinatus tears, often with involvement of the infraspinatus [6]. Boileau reported



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that excessive humeral height more than 10mm was associated with an increased rate of failure of the cuff tuberosity complex and poor clinical result [7]. Version of the humeral prosthesis greater than 40 degrees and age over 75 years and female sex were also associated with reduced clinical outcomes. Following rotator cuff or tuberosity failure, conversion to a reverse shoulder arthroplasty can be considered to accommodate tuberosity non-union and poor rotator cuff function [8]. However revisions are associated with complications, including but not limited to challenges with removal of a well-fixed stem [9].

The development of convertible components, which allow the original humeral stem to be retained, may reduce complications in relation to removal of the stem and operative time [9]. The Global Unite is one of the convertible platform systems [10], with a collar to aid tuberosity fixation and a modular “inlay” body that is fixed inside the humeral shaft, allowing alteration of version and height if desired. This is in contrast to other “onlay” convertible designs in which the reverse body lies superior and outside the cut surface [11]. Convertible constructs may have subtle differences in prosthetic dimension such as head height or offset in comparison to traditional designs. Technical adjustments may be required to avoid stress on the rotator cuff.

We present our experience with Global Unite fracture after noting a high early rate of failure via superior migration. We postulated was that the modular convertible bodies may increase the humeral height in comparison to the non-convertible hemiarthroplasty due the component geometry, leading to early rotator cuff failure.

Materials and Methods

We undertook a retrospective review, and performed a sawbone comparison of the height and offset of the Global FX and the convertible, platform based Global Unite.

Case review

Cases that utilized a Global Unite were identified from medical

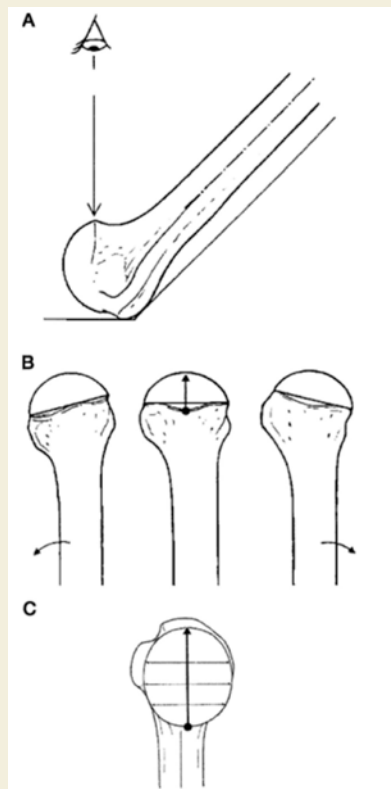


Figure 1: Defining the head equator using Hertel's method. The bones are manually rotated until the base of the head was perpendicular to the axis of the humerus (A and B). The midpoint was determined. A line was then drawn on the head starting from the distal articular midpoint running parallel to the axis of the proximal humerus and bisecting the head (C). (With permission from Hertel, Geometry of the proximal humerus and implications for prosthetic design, JSES 2002).

records. The records and X-rays were assessed for complications retrospectively. The following parameters were assessed on X-ray. Vertical tuberosity displacement was defined as abnormal if the tuberosity united <10 mm below the summit of the head or more than >5 mm above. Horizontal tuberosity displacement was defined as no bone lateral to the prosthesis in the AP X-ray, and the tuberosity seen in the lateral view behind the prosthesis [7]. This implies that the tuberosity has displaced posteriorly due to the pull of the infraspinatus. Proximal migration of the prosthesis was defined on an AP X-ray as an acromiohumeral distance of <7 mm or a >5 mm migration of the center of the prosthetic head from the central axis of the glenoid [12]. This implies that the entire posterosuperior rotator cuff has failed and the humerus is migrating proximally.

Sawbone model

The aim was to compare the Global Unite and Global FX in the same sawbone model to assess the differences in height and offset. A left sided sawbone model was utilized.

Defining the axis of offset

We identified the “distal articular midpoint” as defined by Hertel [13]. Briefly, with the humerus raised at a 45 degree angle to the table, the humerus was rotated until the base of the head was perpendicular

to the axis of the shaft of the proximal humerus. The “distal articular midpoint” was defined as the midpoint along this line. The head equator was then drawn from the distal articular midpoint running parallel to the axis of the proximal humerus and bisecting the head [14]. This line was used to measure offset perpendicular to the axis of the shaft.

The sawbone was fixed into a vice with the two clamps buried into the bone model to prevent movement (Figure 1 and 2).

Marks were made using a set square along the shaft of the humerus parallel to its longitudinal axis. This line was used to align a setsquare to consistently measure height. Height was measured from the proximal tip of the vice, which was a consistent fixed point to the most superior margin of the humeral head (Figure 3).

An anatomic neck cut was made. The shaft was prepared for size 10 Global FX stem. A 52 mm + 18 head was attached. Digital calipers were used for measurements of offset and height along the axis described above. The same bone and cuts were retained. A size 10 Global Unite with a 0 body, size 10 stem and a 52+18 head was inserted. Measurements were made again.

A 52 + 15 head was then measured as recommended by the DePuy technical guide as the equivalent head size to adjust for the prosthetic collar [10]. Smaller heads were then utilized to find the height that was equal to the Global FX.

Results

Clinical series

Six patients (five female, one male) with a mean age of 73.66 years (range 63-82 years) had a Global Unite hemiarthroplasty between



Figure 2: Sawbone held within clamp with long axis of bone defined.

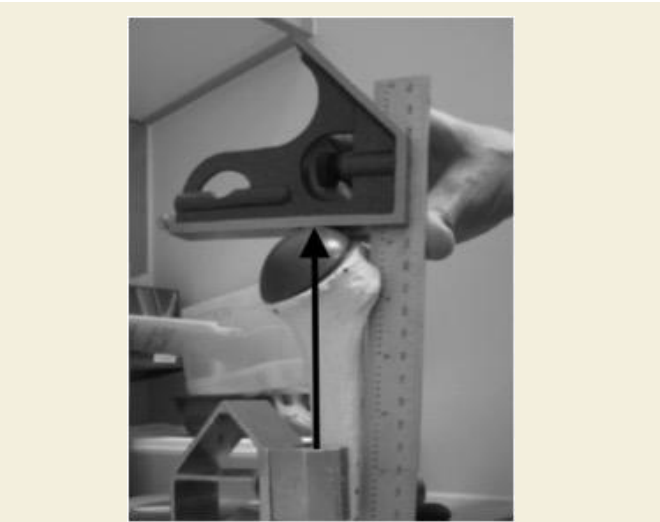


Figure 3: Measurement of prosthetic humeral head height using a setsquare from a fixed point (the superior margin of the clamp). The arrow demonstrates the height measured.

2013-2015. The indications were four part fractures in four patients and fracture dislocations in two. All operations were performed by shoulder fellowship trained Orthopedic surgeons, with four done by a extended deltoid splitting approach as described by Robinson [15], and two by a standard deltopectoral approach. All surgeries were performed acutely at a mean of 5.5 days post injury (range 1-15 days). The post operative rehabilitation was 6w weeks in an immobiliser sling doing passive range of motion with no external rotation beyond 0 degrees. Then active range of motion as the patient tolerated was allowed from 6-12w, then strength work once range is recovered.

Table 1: Results of patients with failed Global Unite.

	Age and sex	Indication	Implant (Global Unite)	Time till failure (months)	Final Tuberosity position	Final Result
1	78F	Failed fracture ORIF with loss of fixation	STEM SIZE 10	3	Intact 12mm below humeral head	Infection
			COLLAR SIZE 44			
			BODY SIZE 10 -5			
			HEAD 44x21			
2	66F	Fracture	STEM SIZE 12	1	Intact 7mm below humeral head	Superior migration
			COLLAR SIZE 44			
			BODY SIZE10 -5			
			HEAD 44x15			
3	82F	Fracture dislocation	STEM SIZE 14		Intact 15mm below humeral head	RadiologicallyINTACT
			COLLAR SIZE44			
			HEAD 44x15			
			BODY SIZE 14 -5			
4	79M	Fracture	STEM SIZE 12	2	Posterior	Superior migration
			COLLAR SIZE 48			
			BODY SIZE 12 -5			
			HEAD 48x18			
5	63F	Fracture dislocation	STEM SIZE 12	9	Posterior	Superior migration
			COLLAR SIZE 44			
			BODY SIZE12 -5			
			HEAD 44x15			
6	74F	Fracture	STEM SIZE 12	12	Posterior	Superior migration
			COLLAR SIZE 44			
			BODY SIZE 12 0			
			HEAD 44x15			

The results of our patients are summarized in (Table 1). Four (66%) failed by superior migration at a mean of 6 months (range 1-12 months) post operatively. Of these, two failed with tuberosities united 7mm below humeral head (Figure 4a and 4b), and two with non-united greater tuberosities. One had a deep infection. One was adjudged to be intact radiographically, with united tuberosities and no superior migration. All patients retained their original humeral stem during revision surgery.

In contrast our previous series of monoblock Global Fx hemiarthroplasties had a lower rate of radiological failure23%. 13 cases were reviewed from 2006. The mean follow up was 4.8yrs (range 1.2 years - 14.9 years). 2 had superior migration, and 1 had a radiologically loose stem.

Sawbone measurements

We noted that the height of the Global Unite was 3.96 mm greater when the same size head (52+18) was used (Table 2). The recommended adjustment of using a 3mm smaller head height (52+15) reduced the height difference to 3.07 mm. Approximate equivalence to the Global FX was achieved with a 44+12 head.

Discussion

We found a 66% failure rate of the Global Unite proximal humeral hemiarthroplasty in our series via a mechanism of superior migration. The Global Unite head height is 3.96mm higher than the Global FX, which we hypothesize may lead to over tensioning of the rotator cuff resulting in a non-anatomical reconstruction, which must be accounted for when using the modular implant.

We postulate that the extra head height of the Global Unite increases the excursion of the supraspinatus and infraspinatus tendon



Figure 4a: Initial postoperative X-ray.



Figure 4b: Failure by proximal migration but a united tuberosity implying a failed rotator cuff.

when the tuberosity is fixed just below the collar. This may place undue tension on the rotator cuff and tuberosity construct, leading to early failure.

Functioning of the rotator cuff is critical to the clinical outcome. Boileau noted that the excessive humeral height compromised the functional outcome [7]. Other factors influencing outcome were final tuberosity position, age over 75 years and being female [7,12]. Similarly, others have also since reported on the poor results in those with mal-united or non-united tuberosities [16-18]. Other

factors recently reported include a critical shoulder angle >38 deg and increased medical comorbidities such as parkinsons disease [19].

The decision on how to manage comminuted fractures in elderly osteoporotic bone or unreconstructable high-energy fractures in younger patients remains difficult, and the results of hemiarthroplasty can be variable. In a randomized controlled trial over 2 years, Olerud noted that a hemiarthroplasty did not improve the range of motion or constant scores in comparison to non-operative measures, however the hemiarthroplasty group had less pain [20]. They noted a 20% loss of position of tuberosities. In contrast Boon reported in their randomized controlled trial that the hemiarthroplasty and non operative group had no difference in pain at 12 m. The non operative group had better abduction strength. Again there was also no difference in constant scores. Superior migration was seen in 20% of the hemiarthroplasty group [21]. In a systematic review in 2008 looking at 810 hemiarthroplasties a proximal migration rate of 6.8% was found. They noted a marked functional limitation as well [17]. The Australian Orthopaedic Association National Joint Replacement Registry (AOA NJRR) reported a 10% revision rate for hemiarthroplasty with rotator cuff insufficiency being the most common revision indication [22].

To produce more reliable outcomes, fracture specific stems have been designed to enhance tuberosity fixation and ultimately union, and these stems may lead to improved tuberosity union and improved constant scores [23-25].

Arthroplasty systems with convertible stems may reduce morbidity in revision negating the requirement for humeral osteotomy and wider dissection. Reduced blood loss, fewer perioperative fractures, fewer nerve palsies and infections when the humeral stem could be retained and converted has been reported. The role of reverse arthroplasty in primary treatment of these fractures is evolving and become more common [26].

One potential benefit of the Global Unite is that its modular components remain inside the humeral cut and supported by bone, the concept of an ‘in lay’ prosthesis. A lack of proximal humeral bone stock surrounding the components may concentrate forces on the joint leading to uncoupling or instability. Catastrophic failure of a modular stems have been reported [27,28]. When the links between the components were outside, and therefore unsupported by, cortical bone. Good results have been reported in primary arthroplasty using the Global Unite shoulder system with revision from anatomic to reverse possible with exchange of the modular components and retention of the humeral stem [29].

A smaller diameter and reduced head height head may reduce the tension on both the infraspinatus and supraspinatus, and this technique has been utilized by Japanese surgeons for hemiarthroplasty [30]. We would recommend making adjustments. The smallest body

Table 2: Comparison of height between Global FX and different sizes of Global Unite.

	Global FX 52+18 mm	Global Unite 52 +18 mm	Global Unite 52+15	Global Unite 44+12
Offset (mm)	52.3	53.11	51.9	49.9
Height (mm)	106.17	110.13	109.24	107.32

should be used and a reduction of head height of 3mm and width should be considered.

The Global Unite prosthesis has been flagged in the Australian Orthopedic Association National Joint Replacement Registry (AOA NJRR) as a prosthesis with a higher than expected revision rate [22]. The cumulative percent revision rate for hemiarthroplasty for fracture is 8% at seven years. For the Global Unite it is 24.7% (73 cases) at two years, with the most common reason for revision being rotator cuff insufficiency (57.1%). This highlights not only a potential problem with this as a hemiarthroplasty, but highlights the value of nationwide, inclusive post market surveillance of new prostheses to guide surgeons in prosthesis selection.

Our paper is a retrospective case series with small numbers. We did not use standardized X-rays and the reasons for failure may be multifactorial.

Conclusion

Early warning regarding unforgiving and technically difficult prosthesis is valuable, and the AOA NJRR data supports our concerns. We recommend that surgeons consider their prosthesis selection carefully with data from multiple sources. In addition to standard techniques, reducing the body and head height should be considered with use of this hemiarthroplasty.

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