

# Hemiarthroplasty versus open reduction internal fixation for intra-articular distal humerus fractures in older patients

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## Abstract

**Background:** Intra-articular distal humerus fractures in the older population remain a challenge to fix, due to the comminution of fragments and poor bone stock. Recently Elbow Hemiarthroplasty (EHA) has gained popularity to treat these fractures, however no studies exist comparing EHA to Open Reduction Internal Fixation (ORIF).

**Objectives:** To compare the clinical outcomes of patients over the age of 60 years treated with ORIF or EHA for multi-fragmentary distal humerus fractures.

**Methods:** Thirty-six patients (mean age 73 years) treated surgically for a multi-fragmentary intra-articular distal humeral fracture were followed up for a mean duration of thirty-four months (12–73 months). Eighteen patients were treated with ORIF and eighteen with EHA. The groups were matched for fracture type, demographic characteristics and follow up time. Outcome measures collected included Oxford Elbow Score (OES), Visual Analogue pain Score (VAS), range of motion (ROM), complications, re-operations and radiographic outcomes. The quality of ORIF was judged against set radiographic criteria in order to understand the effect of sub-optimal ORIF technique.

**Results:** No significant clinical difference was found between EHA and ORIF in mean OES (42.5 vs 39.6,  $p = 0.28$ ), mean VAS (0.5 vs 1.7,  $p = 0.08$ ) or mean flexion-extension arc ( $123^\circ$  vs  $112^\circ$ ,  $p = 0.12$ ). There were significantly more complications associated with ORIF compared to EHA (39% vs 6%,  $p = 0.04$ ). ORIF executed with satisfactory fixation technique had a comparable complication rate compared to EHA (17% vs 6%,  $p = 0.6$ ). Two ORIF patients required revision to Total Elbow Arthroplasty (TEA). None of the EHA patients required revision surgery.

**Conclusion:** This study demonstrated similar short-term functional outcomes between EHA and ORIF for the treatment of multi-fragmentary intra-articular distal humeral fractures in patients >60 years of age. Early complications and re-operations were higher in the ORIF group, although this could be related to improper ORIF technique and patient selection.

## Keywords

distal humerus fracture, elbow hemiarthroplasty, ORIF

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## Introduction

Distal humeral fractures (DHF) account for 2% of all adult fractures and 30% of all elbow fractures.<sup>1–3</sup> Up to 96% of these fractures involve the articular surface.<sup>4</sup> The distribution is bimodal, with a first peak affecting younger individuals with high energy injuries, and a second peak affecting older patients, mainly women, with lower energy trauma.<sup>2,5</sup> For displaced fractures non-operative treatment is reserved for elderly, low demand patients for whom the risks of surgery outweigh the expected benefits.<sup>2,6</sup> Open Reduction Internal Fixation (ORIF) is the gold standard for younger patients, with predictable satisfactory outcomes if anatomical reduction and stable fixation

is achieved.<sup>1,2,5,7,8</sup> Less predictable outcomes are seen with ORIF in older patients because of increased comminution and poor bone quality which contribute to a complication rate reported as high as 48%.<sup>1,4,7,9</sup> These complications include ulnar neuropathy, stiffness, malunion, non-union, heterotopic ossification, post traumatic arthritis and

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metalwork failure.<sup>1,2,4</sup> Total elbow arthroplasty (TEA) is an established alternative to ORIF in this group of patients, with good outcomes in short-term follow up.<sup>9–12</sup> However, TEA introduces a new spectrum of complications and risks that may be more challenging to treat. These include component loosening, poly-ethylene wear and periprosthetic fracture. These risks are known to rise with longer term follow up of TEA performed for trauma.<sup>13</sup>

Recently elbow hemi-arthroplasty (EHA) has gained traction in the treatment of DHF.<sup>12</sup> EHA is thought to provide the benefits of arthroplasty whilst mitigating the long-term complications of TEA.<sup>3,12,14,15</sup> Despite concerns regarding native joint erosion and instability, the short term series reporting EHA are promising with registry data indicating growing numbers of EHA compared to TEA for trauma.<sup>16</sup> It must be noted that the cumulative revision rate for EHA for trauma in the most recent NJR report is 7.67% (95% CI 3.84–15.01) at 2 years.<sup>16</sup> In addition, more contemporary series of ORIF in older patients have demonstrated that good results can be achieved in experienced hands using strict technique and modern implants and it is noteworthy that the studies showing superiority of TEA over ORIF are from a time where modern fixation techniques and implants were not in use.<sup>9,11</sup>

Hence, the aim of this study was to compare the results of EHA with ORIF using contemporary implants in older patients treated for a multi-fragmentary intra-articular distal humeral fracture.

## Material and methods

All patients who underwent surgical fixation for a distal humerus fracture between 2014 and 2020 were identified using the departmental trauma database (Bluespier, UK). For inclusion, the patients required the following criteria:

- A Multi-fragmentary intra-articular DHF AO/OTA Classification 13.B or 13.C.<sup>17</sup>
- Surgical treatment by ORIF or EHA
- Age > 60 years old at the time of surgery
- Minimum 12 months follow up post-surgery

41 eligible patients were identified. 5 patients had died of unrelated causes and were excluded leaving a study population of 36 patients (18 EHA and 18 ORIF).

## Outcome measures

Patient related outcome measures (PROMS) collected were the Oxford elbow score (OES, 0–48),<sup>18</sup> and visual analogue pain scale (VAS 0–10).<sup>19</sup>

Range of movement (ROM) was measured using a goniometer in clinic by the operation surgeon and rounded to the closest 10°.

Clinical and radiographic complications and re-operations were recorded for all patients retrospectively. Those patient with no data were contacted and brought back for review. Clinical complications were documented and recorded prospectively and further radiographic complications not picked up prospectively were derived from retrospective analysis of all post operative x rays. Heterotopic Ossification (HO) was only classified as a complication if it was associated with symptomatic stiffness e.g. HO in the region of the collateral ligaments was not classed as a complication. For the EHA group, wear in the native ulna and radial head was recorded. Non-union of the epicondyles in the EHA group was not classified as a complication unless it was associated with pain, instability or progressive migration of the epicondyle on serial x rays as asymptomatic non-union has not been demonstrated to affect outcome after EHA.<sup>3</sup> The radiographic appearance of wear was not classed as a complication unless it was associated with pain or stiffness.

In the ORIF group, non-union and fixation failure (hardware breakage or secondary displacement) were counted as one complication if both were present in the same patient and individually if for instance only a non-union was present without problems with the metalwork. Degenerative changes in the UHJ or RC joints were not classed as a complication unless they were clearly associated with pain or stiffness.

For the ORIF group, intra-operative fluoroscopic views were assessed to grade whether fixation was satisfactory. In order to be deemed ‘satisfactory’ the following criteria were required:

- Anatomic reduction of articular block with <2 mm step
- Restoration of correct sagittal and coronal plane alignment
- Minimum use of one plate per fractured column
- Screws engaging all articular fragments and interdigitating between plates
- Coronal shear fragments stabilised with independent plates and/or screws

See Tables 1 and 2 for patient demographics and results.

These criteria were based on pre-existing recommended parameters for distal humerus ORIF.<sup>20</sup>

## Surgical technique

All EHA cases were performed by a single fellowship trained elbow surgeon. A lateral para-olecranon approach was used in all cases and the technique used was as described by Phadnis et al.<sup>12</sup>

Four different surgeons performed the ORIF cases. All were either fellowship trained trauma or shoulder and elbow surgeons. Five patients had an olecranon osteotomy and 13 had either a para-triceps or lateral para-olecranon approach. Fixation was performed using modern pre-

**Table 1.** Demographics and results of hemi-arthroplasty patients.

Case	Age (Sex)	Open/Closed	AO/OTA Classification	Side	ASA Grade	OES	VAS	FE Arc°	Complications	Wear (r = radial, u = ulna)	Re-operation	FU (months)
1	83 (F)	C	C3.3	L	3	46	0	125	n	n	n	56
2	66 (F)	C	B3.3	R	2	42	0	135	n	n	n	48
3	76 (M)	O	C3.3	L	2	32	2	100	UN parasthesia	U, R	UN Decompression	48
4	69 (F)	C	C3.1	R	2	42	0	140	Epicondyle NU	n	n	51
5	81 (F)	C	C3.1	L	2	43	1	130	n	U, R	n	36
6	65 (F)	O	C3.1	L	2	40	0	120	n	R	n	36
7	82 (F)	C	C3.1	L	2	46	0	125	n	n	n	38
8	86 (F)	C	C3.1	L	2	43	1	135	n	n	n	36
9	69 (F)	C	C3.3	L	2	44	0	140	n	n	n	36
10	67 (F)	O	C3.1	R	2	41	0	130	n	n	n	28
11	73 (F)	C	C3.2	L	3	48	0	140	Epicondyle NU	n	n	24
12	62 (F)	C	C3.1	R	3	44	0	120	n	n	n	24
13	85 (M)	C	C3.3	L	2	41	1	100	n	n	n	18
14	71 (F)	C	B3.3	R	2	45	0	120	n	n	n	20
15	70 (F)	C	C3.1	L	2	47	0	140	Epicondyle NU	n	n	16
16	85 (F)	C	C3.1	L	2	37	3	80	n	n	n	20
17	70 (F)	C	C3.1	L	3	43	0	110	n	n	n	19
18	81 (F)	C	C3.3	R	3	41	1	125	n	n	n	18

Table 2. Demographics and results of ORIF patients.

Case	Age (Sex)	Open/ Closed	AO/OTA Classification	Side	ASA Grade	OES	VAS	FE Arc°	Complications	Re-operation	Satisfactory Fixation	FU (months)
1	64 (F)	O	B3.3	L	2	42	0	130	UN parathesia, Deep Infection, Fixation failure, HO	2 stage TEA	n	49
2	82 (F)	O	C3.3	R	2	21	6	90	Non-union, HO, Fixation failure	Revision ORIF	n	20
3	70 (F)	C	B3.3	L	2	37	2	110	n	n	y	31
4	64 (M)	O	C3.1	L	1	48	0	110	n	n	y	31
5	64 (M)	O	C3.3	L	2	40	1	120	UN & RN parathesia	n	n	30
6	66 (F)	C	C3.3	R	2	19	7	95	UN parathesia	UN Transposition, Capsular Release	y	20
7	76 (F)	C	B3.3	L	2	48	0	130	n	n	y	16
8	83 (F)	C	C3.2	R	3	44	0	90	HO	n	y	13
9	72 (F)	C	C3.3	R	2	39	2	120	n	n	y	15
10	73 (F)	C	B3.3	L	2	47	0	130	n	n	y	26
11	65 (F)	C	C3.1	L	1	48	0	140	n	n	y	72
12	71 (F)	C	C3.2	L	1	47	0	130	n	n	n	44
13	67 (F)	C	C3.3	R	1	48	0	130	n	n	y	47
14	63 (F)	C	C3.1	L	2	22	5	70	Fixation failure	2 stage TEA	y	13
15	81 (M)	C	C3.1	R	2	48	0	130	n	n	y	73
16	71 (F)	C	C3.2	R	1	44	0	130	n	n	y	72
17	75 (M)	C	C3.2	L	2	46	0	120	HO	Hardware removal, Capsular Release	n	64
18	80 (F)	C	C3.3	L	2	25	7	40	HO, Malunion, Backout of wires	Hardware removal	n	62

contoured plates in an orthogonal, parallel or hybrid configuration (posterolateral plate with outrigger tab allowing parallel screw fixation) depending upon the fracture and determined by surgeon preference. A single posterolateral plate was used in four type B fractures with a predominantly coronal shear fracture pattern. In all other cases two plates were used.

The ulnar nerve was managed according to surgeon preference with either in situ decompression or anterior transposition on a case by case basis in both groups.

### Statistical analysis

The Mann Whitney-U test<sup>21</sup> was used for non-parametric continuous data. Categorical variable were assessed using Fisher exact test.<sup>22</sup> Data was analysed using Microsoft Excel (Windows 10 version).

## Results

Five patients had died of unrelated causes and were excluded leaving a study population of 36 patients (18 EHA and 18 ORIF). Of the patients that died no follow up information was available before their death (either clinical or radiographical). All patients included had full follow up data. Patient level data for the EHA group is provided in table 1. Mean age was 74.5 years  $\pm$  7.9 years (range 62–86 years). Mean follow up time was 32 months  $\pm$  12 months (range 18–56 months). Patient level data for the ORIF group is provided in Table 2. Mean age was 72 years  $\pm$  6.8 years (range, 63–71 years). Mean follow up time was 38 months  $\pm$  22 months (range 13–73 months).

### Group comparison

There was no significant difference in patient demographics (age, sex, affected side, open/closed fracture, or ASA grade) or follow up time between the two groups. In the hemiarthroplasty group 10 patients underwent ulnar nerve transposition, compared to 3 in the ORIF group. ( $p = .015$ ). All hemiarthroplasties were performed by a single surgeon who recently started routinely transposing the ulnar nerve in arthroplasty cases.

There was no significant difference in the AO classification type between the groups. However, there were more patients with a predominantly articular fracture (AO type B3.3 or C3.1) in the EHA group ( $n = 12$ , 67%) than the ORIF group ( $n = 8$ , 44%),  $p = 0.31$ . Figures 1 and 2.

### Range of motion

There was no significant difference in the mean flexion arc between the groups (EHA  $120^\circ \pm 20^\circ$  vs ORIF  $110^\circ \pm 30^\circ$ ) ( $p = 0.12$ ). Terminal loss of extension was less in the EHA group  $10^\circ \pm 10^\circ$  vs. the ORIF group  $20^\circ \pm 10^\circ$ , ( $p = 0.03$ ).

### VAS and OES

There was no significant difference in the mean VAS between the groups (EHA  $0.5 \pm 0.9$  vs. ORIF  $1.7 \pm 2.6$ ) ( $p = 0.08$ ).

There was also no significant difference in the mean OES between the groups (EHA  $42.5 \pm 3.8$  vs. ORIF  $39.6 \pm 10.4$ ) ( $p = 0.28$ ).

### Complications and Re-operations

**EHA group.** There was one complication (6%) in one patient. This was an ulnar nerve injury (patient 3). He had an open fracture treated with a staged washout, debridement and implantation of the prosthesis three weeks after the original fracture with motor and sensory injury from the ulnar nerve that developed after the hemiarthroplasty implantation. He underwent exploration and neurolysis at three months where the nerve was found to be in continuity. There was incomplete long term nerve recovery and this patient also had the lowest outcome scores in the EHA group.

No other clinical complications were observed.

Radiographic analysis revealed four patients with non-union of the one of the repaired epicondyles. All were asymptomatic and did not result in elbow instability. There was no migration of the epicondyles on serial x rays consistent with well healed ligaments.

One patient had evidence of asymptomatic HO on x ray and they retained a  $140^\circ$  flexion arc.

**ORIF group.** There were fifteen complications in seven patients (39%). Four patients developed ulnar neuropathy ( $n = 4$ , 22%). One patient had expectant treatment, one underwent open ulnar nerve transposition and arthroscopic arthrolysis; one underwent revision ORIF, then staged elbow replacement and the last had removal of metalwork and ulnar nerve neurolysis. Three of these patients (75%) had persistent ulnar nerve symptoms despite re-operation.

Five patients (28%) had symptomatic stiffness with associated HO. Four of these underwent re-operation. One had removal of metalwork and open release, one had arthroscopic arthrolysis, one had revision ORIF due to associated non-union and the last had removal of prominent wires from an olecranon osteotomy no further surgery for the stiffness.

Three patients (17%) had failure of their fixation with broken metal work or fracture displacement. Two underwent staged conversion to TEA and one underwent revision ORIF. Both these patients had AO 13.C3.1 fractures (low multi-fragmentary fractures with a coronal shear component) (Figure 3). The other patient had an AO type C3.3 fracture that developed a supracondylar non-union and broken metal work requiring revision ORIF. All revision procedures have been successful to date.



**Figure 1.** a,b: Comminuted distal coronal shear fracture. c,d: Successful treatment with hemiarthroplasty.

Wire prominence, radial neuropraxia and deep infection each occurred once (6%) in three separate patients.

ORIF patients with complications had a significantly lower OES (30.7 vs 45.3,  $p = 0.001$ ), higher VAS (3.7 vs 0.4,  $p = 0.004$ ) and lower FE-arc ( $95^\circ$  vs  $123^\circ$ ,  $p = 0.02$ ).

**Group comparison.** The complication rate in the ORIF group was significantly higher (6% vs 39%,  $p = 0.04$ ). One patient in the EHA group sustained a simultaneous wrist fracture. In the ORIF group one patient sustained a concomitant hip fracture, and one was a polytrauma with several other severe limb injuries.

Based on the previously defined criteria in the ORIF group, twelve (67%) patients had satisfactory fixation and six (33%) did not. Patients without satisfactory fixation

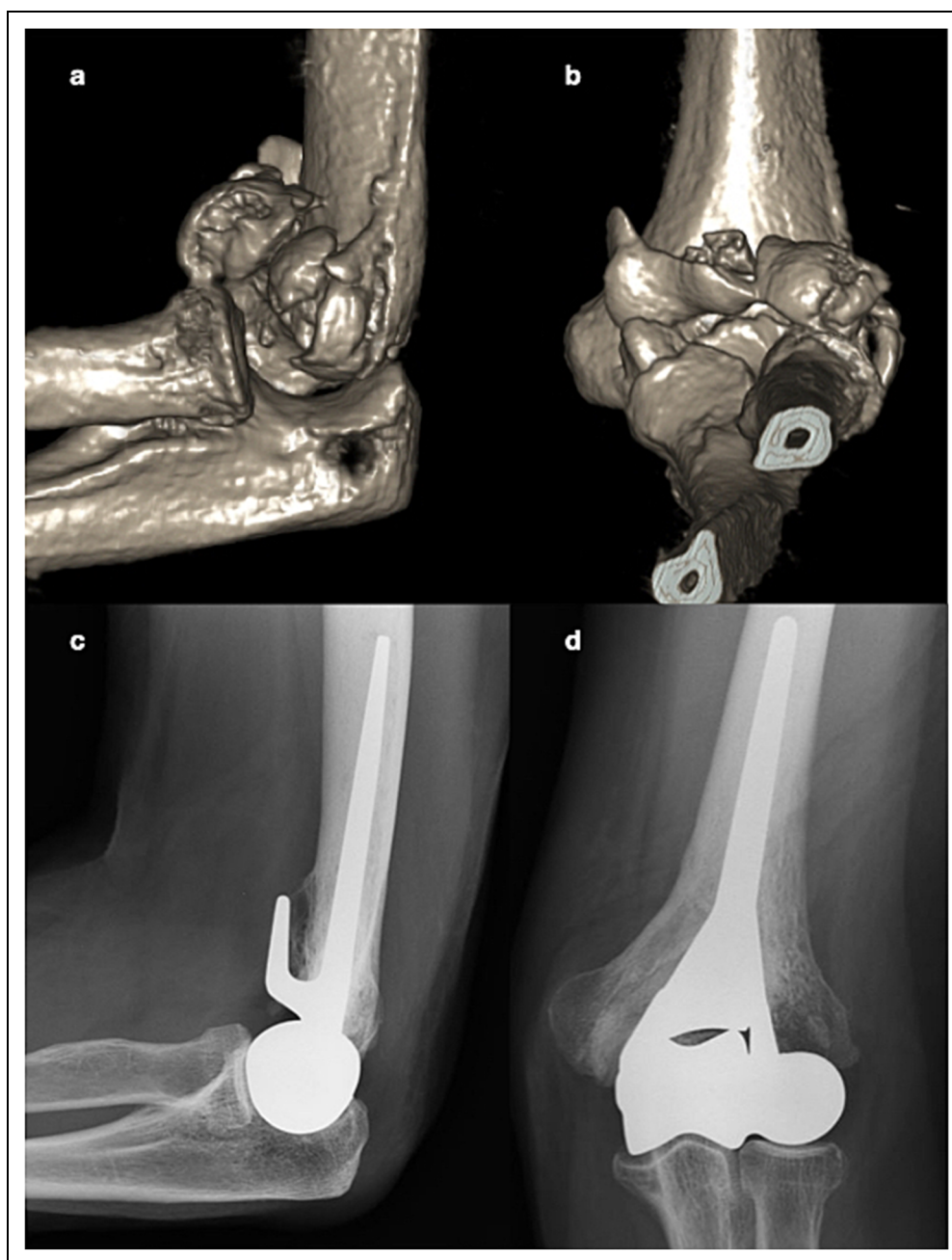
had a significantly higher complication rates (83% vs 17%,  $p = 0.01$ ).

There was no significant difference in the complication rate of patients with satisfactory fixation compared to the EHA group (17% vs 6%,  $p = 0.6$ ).

## Discussion

The objective of this study was to compare the clinical outcome and complication profile of ORIF and EHA for multi-fragmentary distal humeral fractures in older patients. To our knowledge this is the first study to do this. Prior comparative studies have suggested superiority of TEA over ORIF for complex fractures in older patients, however, these studies which are frequently cited used



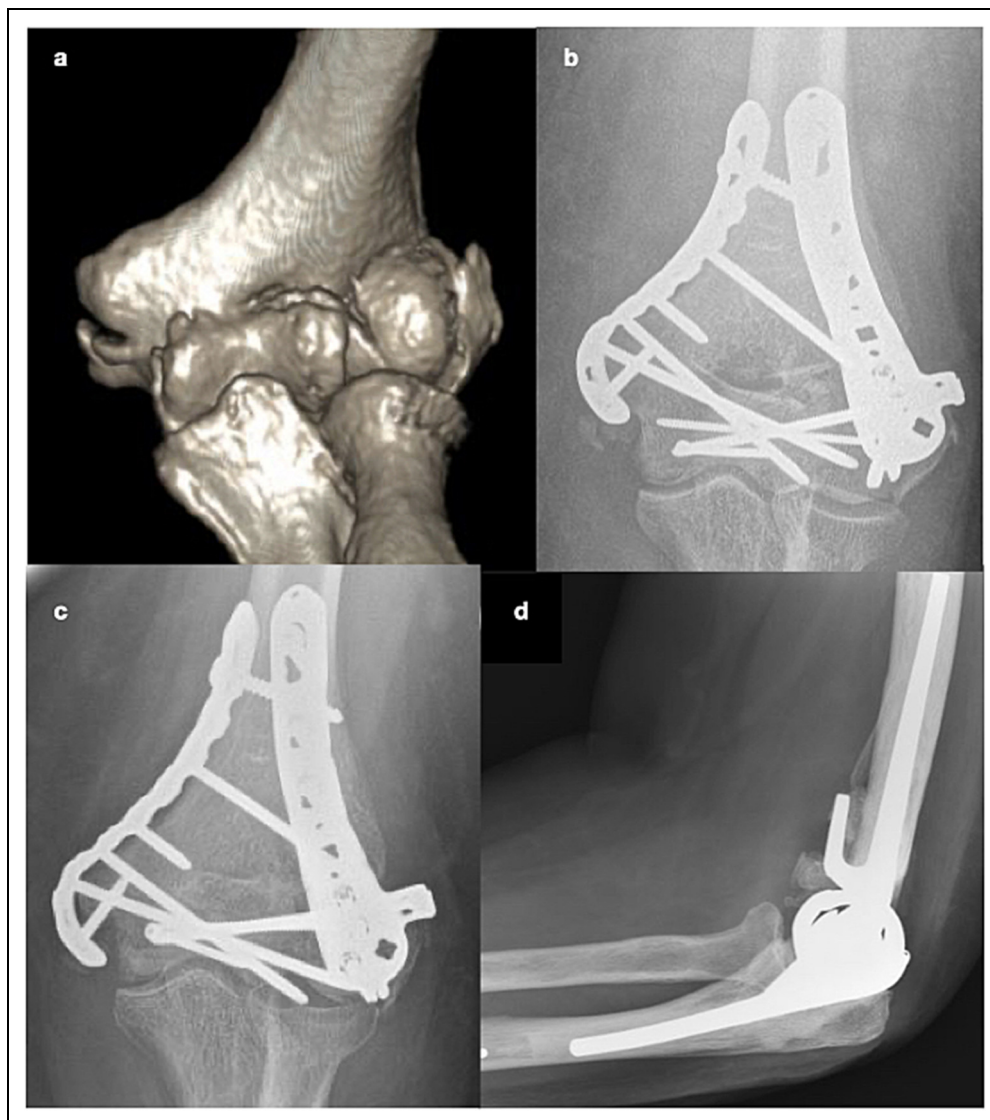


**Figure 2.** a: Both column distal humerus fracture. b,c: Successful treatment with olecranon osteotomy and ORIF.

older fixation implants that are no longer in common use. Hence, it was felt there was value in assessing a ‘modern’ fracture arthroplasty (EHA) with modern fixation implants and techniques.

The headline findings of the present study could either be that ‘there is no significant difference in functional outcome between EHA and ORIF’ or that ‘ORIF has a significantly higher complication rate than EHA’. We feel it is important that both these headlines are tempered by the finer points and limitations of this study. One such limitation was that the EHA cases were all performed by a

single surgeon with extensive elbow arthroplasty and elbow trauma experience whereas the ORIF group was performed by several surgeons, although all were either fellowship trained shoulder and elbow, or trauma surgeons. While this could be construed as a limitation, this is actually a true reflection of modern practice. In the UK for instance, there has been a mandate for elbow arthroplasty procedures to be centralised to ‘expert’ centres, whereas the same has not happened for complex trauma.<sup>23,24</sup> In contrast, complex distal humeral ORIF is performed by a wider demographic of surgeons including trainees and non-specialist



**Figure 3.** a-c: Very distal coronal shear fracture. c-d: Intra-operative imaging. e-f failure for fixation : Subsequent revision to total arthroplasty.

consultants who have a relatively low volume elbow or trauma practice.

It was our intuition at the outset of this study that elbow arthroplasty performed in the right hands is a more reproducible procedure compared to fracture fixation, which requires a variety of techniques and implants that must be tailored to the individual fracture and patient personality. In order to better understand the effect of fixation technique, we performed a sub group analysis of patients who had optimal fixation and those where the fixation technique was deemed sub-optimal in hindsight. This is a variable that has not been discussed or included in previous comparative studies. Our findings demonstrated that the higher complication and re-operation rate was primarily associated with sub-optimal fixation and that when the

quality of fixation was satisfactory the complication rates were not statistically different (17% ORIF vs. 6% EHA). The inclusion of the sub-optimal fixation patients does skew the results however, we feel inclusion of these patients is important for several reasons. Firstly, this reflects widespread practice where not every surgeon is equally adept at achieving stable fixation of a highly complex fracture. Secondly, it highlights that every multi-fragmentary fracture is not all the same, and that some are truly unreconstructable. In this scenario, an attempt at ORIF may be doomed to failure even in the best hands.

Hence, given our findings that good outcomes can be achieved with ORIF in many fractures, the decision making on which fractures are most suitable for arthroplasty is critical.



Particular patterns of fracture that are known to be especially challenging to treat are, low comminuted fractures predominantly affecting the articular surface and sparing the columns. Many of these have coronal shear fragments with poor bone stock.<sup>25</sup> Indeed, there were more patients in the EHA group with this type of fracture indicating a pre-operative selection bias towards arthroplasty. Furthermore, two of the three fractures that had failure of fixation in the ORIF group were low articular fractures (AO C3.1) in female patients. One of these was in the satisfactory fixation group and both required conversion to TEA. Given the good results of the EHA group better pre-operative selection may have improved the outcome of these patients. Although the numbers are small, our data suggests that surgeons should be more cautious when considering ORIF in predominantly articular fractures and may favour arthroplasty if the patient factors are suitable. For fractures with a coronal shear element the Dubberley Classification could help the surgeon differentiate between treatment options.<sup>25</sup>

Despite a significant difference in the overall complication rate between the two groups, the overall PROMS and ROM were similar. However, the PROMS, VAS and ROM were all significantly lower in patients who had a complication. Patients without a complication had similarly good scores to those in the EHA group further substantiating the finding that good outcomes are achievable with ORIF if patient selection is correct and attention is paid to technical detail.

It is important to acknowledge that this is a short term follow up study with regard to the EHA patients (mean 32 months) and that while the results of ORIF are likely to improve or plateau with time, the results of arthroplasty are likely to deteriorate as longer-term complications such as native joint wear occur. This is certainly the case for TEA and although the short and mid-term outcomes of EHA appear to show a low rate of complications, long-term high-volume studies are awaited.<sup>1,5,9,12,13</sup>

## Conclusion

Overall patient reported outcomes of EHA and ORIF were comparable for the treatment of multi-fragmentary distal humeral fractures in older patients. However, the complication rate of ORIF was higher and patients with a complication had inferior PROMS. ORIF outcome was sensitive to variations in surgical technique and patient selection for ORIF.

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