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Internal fixation of a periprosthetic fracture after Copeland shoulder resurfacing. A case report, literature review, and proposed treatment algorithm

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Periprosthetic fractures after Copeland shoulder resurfacing arthroplasty are rare, but when they occur, they pose a significant therapeutic dilemma. Only a few cases have been reported in the literature.[1-3,5,6,12,14] In periprosthetic fractures after shoulder resurfacing, the main treatment option is anatomic or reverse shoulder arthroplasty. Successful treatment with open reduction and internal fixation with a plate has not yet been reported in the literature.

We present a case with periprosthetic fracture after Copeland shoulder arthroplasty, which was successfully treated with open reduction and internal fixation with a plate.

Statement of informed consent

The patient was informed that data concerning the case would be submitted for publication and has agreed. The patient has provided informed and written consent for the publication of the data and the radiographs of this case.

Case report

A 58-year-old female patient with primary shoulder osteoarthritis underwent Copeland cementless shoulder resurfacing arthroplasty (Zimmer-Biomet) 35 months prior to a serious fall from the stairs when she suffered a periprosthetic fracture. In the initial operation, a deltopectoral approach was used. The rotator interval was identified and longitudinally incised along the line of the long head of the biceps to define the insertion of subscapularis. Subscapularis was then detached. The humeral head was replaced with a Copeland humeral resurfacing head and the divided subscapularis tendon was repaired and reattached using a Healix Ti titanium anchor (Mitek, Johnson and Johnson) (Fig. 1). The patient followed a supervised physiotherapy program and returned to activities with restoration of the range of motion and lack of pain. She had regular follow-ups with no postop complications.

The patient presented to the hospital with left shoulder pain and decreased mobility following a fall. She was neurovascularly intact. X-ray examination revealed the presence of a comminuted fracture of the anatomical neck on her left shoulder. The fracture line was crossing the anchor hole (Fig. 2). A CT was performed to adequately visualize the fracture type and comminution and to assist in the preoperative planning. There were no signs of radiolucency around the implant and the resurfacing head, and there were no fracture lines extending around it. There was also no sign of glenoid erosion. The possible treatment options were explained to the patient, and it was decided that she would benefit from an open reduction and internal fixation (ORIF)

This study was conducted at the 2nd Orthopaedic Department for Arthroscopic and Shoulder Surgery, Metropolitan General Hospital, Athens, Greece.
Institutional Review Board approval was received from the Metropolitan General Hospital Scientific Committee.

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Figure 1 Postoperative radiograph after Copeland shoulder resurfacing operation. A metallic anchor was used to reattach the divided subscapularis tendon.

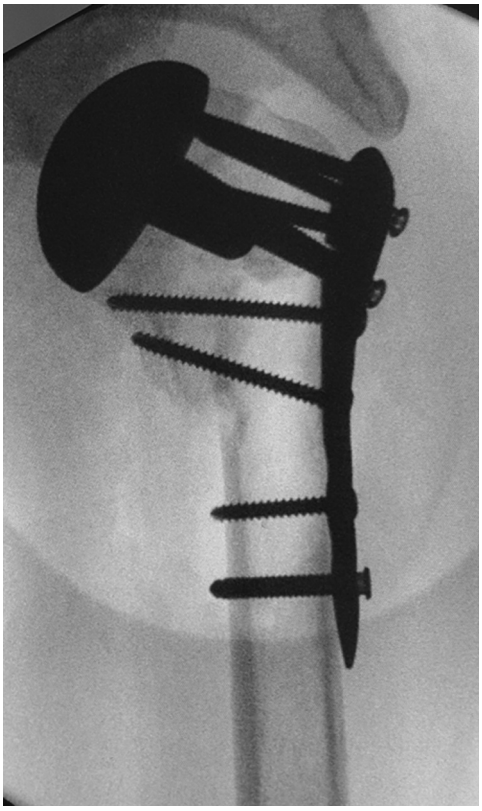

Figure 3 Intraoperative fluoroscopic view of the internal fixation. The plate screws extend to the level of the humeral cup.

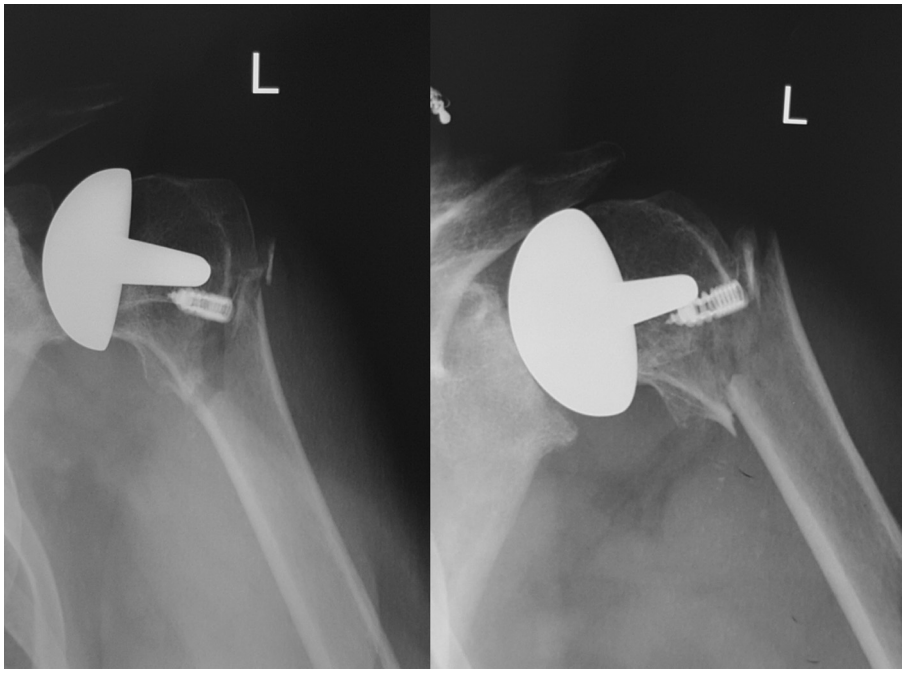

Figure 2 Periprosthetic fracture after Copeland shoulder resurfacing operation. The fracture line extends through the anatomical neck of the humeral head crossing the anchor hole.

with a proximal humerus plate. The patient was informed that the case would be submitted for publication, and she provided written consent. The patient was placed in a beach chair position and a standard deltopectoral approach was used. The fracture was reduced under fluoroscopic control, and it was stabilized with an anatomic proximal humerus plate (AxSOS, Stryker). The titanium anchor for subscapularis repair was loose and was removed. Due to the lack of cement and the preservation of bone stock, the use of multiple screws was possible without any difficulty (Fig. 3).

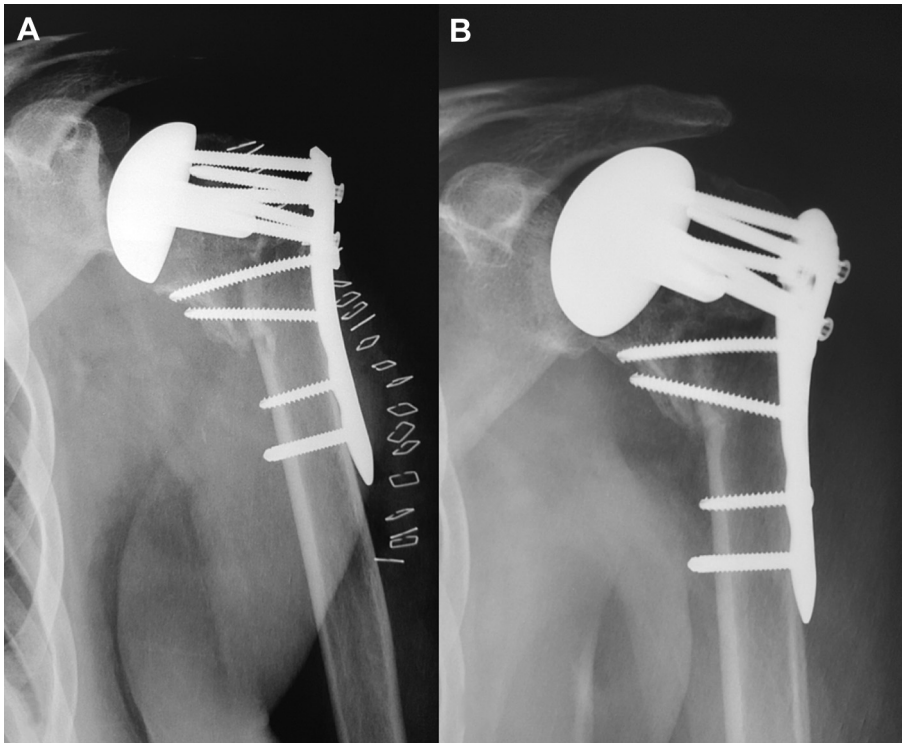

Figure 4 Immediate postoperative radiograph (**A**) and a radiograph showing the healing of the fracture (**B**).

The postoperative period was uneventful and a gradual return to activities was instituted. After the ORIF the patient was followed up for 41 months. Satisfactory fracture healing was achieved with no complications (Fig. 4), and the patient was able to achieve a significant range of motion with active forward flexion of 170°, active abduction of 160°, internal rotation of 50°, and external rotation of 60°. The Constant shoulder functional score was used to estimate the patient's level of function before the arthroplasty, after the arthroplasty, and after the ORIF of the periprosthetic fracture. The Constant score was 23 before the arthroplasty and this was significantly improved to 71 after the Copeland CSRA. After the periprosthetic fracture and the successful management with an ORIF as described above, the patient achieved a Constant score of 68. This demonstrates that the patient managed to have a satisfactory recovery maintaining a high level of shoulder function without the need for major revision surgery (Table I).

Discussion

The case we are presenting is, to our knowledge, the first to describe the successful treatment of a periprosthetic fracture around a well-fixed Copeland cementless surface replacement arthroplasty (CSRA). Copeland CSRA was introduced as an alternative to total shoulder arthroplasty, hemiarthroplasty, and reverse shoulder arthroplasty for the treatment of shoulder arthritis in young and active patients.[8]

Copeland CSRA is a minimally traumatic operation, which can effectively restore normal humeral head inclination, version, and offset. The CSRA can restore anatomy by adapting the position of the prosthesis to the normal anatomy of the patient. The components are not placed in any fixed angle of inclination, retroversion, or offset but are intended to reproduce the patient's anatomy.

Periprosthetic fractures are a relatively uncommon but significant complication of shoulder arthroplasties. These complications are of particular importance, as they frequently lead to the need for revision surgery. Periprosthetic fractures after Copeland cementless surface replacement arthroplasty are most commonly treated with revision shoulder arthroplasty using total or reverse shoulder replacement.[3,5,9,14]

The overall risk of periprosthetic fractures after shoulder arthroplasty is relatively low, ranging between 0.6% and 3%.[11] In a series of 4019 TSA and humeral head replacements, the incidence of postoperative periprosthetic fractures was 0.4% (18/4019).[5] The incidence of intraoperative fractures was similar at 0.37% (15/4019).[5] Anatomical shoulder arthroplasty appears to have higher rates of periprosthetic fractures compared to humeral head replacement. These fractures can take place intraoperatively or postoperatively, occurring 0.9–3.5% and 1.0–3.0% of the time, respectively.[5] Regarding the reverse total shoulder arthroplasty, a large systematic review published in 2021 analyzing 20 different implant systems found out that the overall rate of postoperative periprosthetic fractures was 1.3%.[10]

Table I
The clinical scores of the patients prior to the first operation, 32 months later, and at the latest follow-up, 17 months after the intenal fixation of the periprosthetic fracture.

Clinical score	Pain (0-15)	Constant score	Active forward flexion	Active abduction	External rotation	Internal rotation
Preoperative scores before arthroplasty	6	23	90	60	20	20
Follow-up scores after arthroplasty	0	71	170	150	60	50
Follow-up scores after ORIF for periprosthetic fracture	0	68	170	160	50	50

Table II
Review of the major clinical series reporting the outcome after CRSA. The incidence of periprosthetic fractures and their treatment is presented.

Study	Authors	Year	Number of cases	Follow up	% Satisfied patients	Fractures	Treatment
Cementless surface replacement arthroplasty of the shoulder. 5 to 10-yr results with the Copeland Mark 2 prosthesis.	Levy O, Copeland SA.[6] J Bone Joint Surg Br 2001; 83:213-21	2001	285 cases	6.8 yr	93.9%	1 case (0.3%) 1.75 yr postoperatively fracture at the margin of the humeral head replacement	Revision to TSA
Copeland Surface Replacement Arthroplasty of the Shoulder in Rheumatoid Arthritis.	Levy et al.[7] J Bone Joint Surg Am 2004; 86(3):512−518,	2004	75 33 hemiarthroplasties and 42 total shoulder arthroplasties	6.5 yr	96%	0	
Surface replacement arthroplasty for glenohumeral arthropathy in patients aged younger than fifty yr: results after a minimum ten-year follow-up.	Levy et al. J Shoulder Elbow Surg. 2015;24(7):1049-60.	2015	54 CRSA on 49 patients 25 men, 24 women younger than 50 yr	mean follow-up 14.5 yr (range 10-25 yr)	81.6%	1 case	TSA
Surface Replacement Arthroplasty of the Humeral Head in Young, Active Patients: Midterm Results.	Iagulli et al.[4] Orthop J Sports Med. 2014;2(1):2325967113519407.	2014	118 cases 22 Biomet Copeland prosthesis (Warsaw, Indiana, USA) 26 DePuy Global cap (Raynham, Massachusetts, USA) mean age 48 yr (range, 21-59 yr).	6 yr (range, 4-8 yr)	94%	0	–
Cementless surface replacement arthroplasty of the shoulder for osteoarthritis: results of fifty Mark III Copeland prosthesis from an independent center with four-year mean follow-up.	Hadithy, et al.[3] J Shoulder Elbow Surg. 2012;21(12):1776-81.	2012	53 Mark III Copeland CRSA hemiarthroplasties 46 patients (30 women, 16 men) age 45-94 yr (mean 69)	4.2 yr	70%	1 case (1.8%) At 2 yr 3-part periprosthetic fracture at the tip of the short peg after a traumatic fall	Revision stemmed cemented hemiarthroplasty
Clinical and radiological results 7 yr after Copeland shoulder resurfacing arthroplasty in patients with primary glenohumeral osteoarthritis: an independent multicentre retrospective study.	Verstraelen et al.[14] Eur J Orthop Surg Traumatol 2018;28:15−22.	2018	33 CRSA in 27 patients 18 women mean age 67.7 yr (50.2−85.1)	7.2 yr	83.7%	1 case (3%) due to a direct trauma 92 mo after implantation	Revision to RSA
Long-term follow-up of the Copeland mark III shoulder resurfacing hemi-arthroplasty.	Rai et al.[9] J Orthop 2015;13(1):52−58	2015	85 patients (95 shoulders) CRSA hemiarthroplasty 40 patients (46 shoulders)	12 yr	88%	3 cases (6.5%) 1 atraumatic periprosthetic fracture 11 yr postoperatively 1 traumatic periprosthetic fracture 12 yr and 2 mo after the index operation 1 traumatic greater tuberosity periprosthetic fracture 27 mo after the index operation	Case 1: Revision to a reverse prosthesis Case 2: Revision surgery Case 3: Nonunion of a greater tuberosity fracture was revised to a total shoulder replacement
Mid-term results of Copeland shoulder cementless surface replacement arthroplasty from an independent centre.	Hwang et al.[5] Shoulder Elbow. 2014;6(2):75−80	2014	112 in 101 patients median age 75 yr (range 41-89 yr)	72 mo (range 9 -121)	87.7%	3 cases (2.6%) 2 cases conservative treatment 1 case nonunion	Revision to TSA
Outcome of Copeland surface replacement shoulder arthroplasty.	Thomas et al.[12] J Shoulder Elbow Surg 2005;14(5):485−491	2005	56 Mark 3 Copeland humeral head surface	34.2 mo	91.9%	1 case (1.8%) 2-part humeral neck fracture	Nonoperative treatment Fracture healing at 3 mo

(*continued on next page*)

Table II (*continued*)

Study	Authors	Year	Number of cases	Follow up	% Satisfied patients	Fractures	Treatment
			replacement hemiarthroplasties				
Periprosthetic humeral fracture after Copeland resurfacing and the role of revision arthroplasty: A report of three cases.	MacLean et al. Int J Shoulder Surg. 2015; 9(4):128-30.	2015	–	n/a	n/a	3 cases of traumatic periprosthetic fractures	2 cases TSA 1 case RSA
Outcome of Copeland Shoulder Resurfacing Arthroplasty With a 4-yr Mean Follow-Up	Alizadehkhaiyat et al. J Shoulder Elbow Surg. 2013 Oct;22(10):1352-8.	2013	102 cases Copeland Mark IV	4 yr (range, 2-9)	85%	0 cases	–
Results and limitations of humeral head resurfacing: 105 cases at a mean follow-up of 5 yr.	Soudy K. et al. Traumatol Surg Res. 2017;103(3):415-420.	2017	40 Copeland 65 Aequalis humeral resurfacing Mean patient age 64 yr	56 mo (24-120)	61.9%	0 cases	–
Long-term results and patient satisfaction after shoulder resurfacing.	Pritchett JW J Shoulder Elbow Surg. 2011;20(5):771-777.	2011	61 patients (74 shoulders) minimum follow up 20 yr Total Articular Replacement Arthroplasty prosthesis (DePuy Orthopaedics and Howmedica)	mean follow-up 28 yr (range, 20-41 yr)	95%	0 cases	–

CRSA, Cementless resurfacing shoulder arthroplasty; *n/a*, not available; *TSA*, Total shoulder arthroplasty; *RSA*, Reverse shoulder arthroplasty.

Periprosthetic fractures after Copeland CSRA have also been reported to be uncommon. The incidence of periprosthetic fractures after Copeland CSRA ranges from 0.3% (Levy 2001)[5] to 6.5% (Rai P 2015).[9] The fractures identified in the above papers do not appear to have any significant similarities and are found more often in a specific portion of the implant. In another 3 large series, including 272 patients no periprosthetic fractures were reported.[3,4,7]

The reasons for the low rate of periprosthetic fractures are not clearly identified in the literature, but some possible factors are suggested. In their paper, Levy and Copeland identified that cementless surface arthroplasty diminishes the risk of complications involving the humeral shaft and periprosthetic fractures.[6] The main reason for the low rate of periprosthetic fractures could be the fact that stemmed prosthesis creates a stress riser effect at the tip of the shaft in the midshaft of the humerus, something that is avoided with stemless prosthesis. They also suggested that revision or arthrodesis were easily undertaken as the bone stock was maintained with no loss of length. Additionally, they mentioned no major intraoperative complications such as periprosthetic fractures or perforation of the shaft of the humerus. The reason for that was that no preparation of the humeral intramedullary canal has been required.

In Table II the clinical series with or without a periprosthetic fracture following Copeland CSRA are presented. The low rates of periprosthetic fractures are consistently seen through the literature. As seen in Table II, five studies, including 474 cementless resurfacing shoulder arthroplasties did not identify any periprosthetic fractures. Furthermore, in another eight studies, including 688 cementless resurfacing shoulder arthroplasties, only 14 periprosthetic fractures were identified. Out of these 14 fractures identified, 6 were revised to total shoulder arthroplasty, 1 to cemented hemiarthroplasty, and 3 to reverse shoulder arthroplasty. There were 3 cases of periprosthetic fractures that were managed with nonoperative treatment leading to fracture healing in a period of 3 months, with no further complications and no need for revision. There was 1 case of a patient that was initially managed conservatively, which led to a nonunion. This was later revised to a TSA.

Regarding the management of periprosthetic fractures around stemless resurfacing arthroplasties and anatomical or reverse shoulder arthroplasties, there is no study directly comparing the outcomes in between those categories. However, a number of unique characteristics of the cementless resurfacing arthroplasties suggest that treatment of periprosthetic fractures around them could potentially have a better outcome. Surface replacement arthroplasty does not require removal of a significant amount of bone stock of the proximal humerus. As a result, all the bony landmarks around the shoulder and a significant amount of bone stock are maintained. Additionally, surface replacement arthroplasty does not require access to the intramedullary canal as there is no stem inserted. All the above differences from the traditional stemmed arthroplasties either anatomical or reverse could lead to a technically easier revision and potentially better outcomes.

Furthermore, the preservation of the bone stock and the lack of a stemmed prosthesis could potentially allow for conservative management of minimally displaced periprosthetic fractures. We have identified three such cases in the literature, in which 2-part humeral neck periprosthetic fractures were managed nonoperatively and were successfully healed in a period of 3 months.[5,12]

With the progressive ageing of patients who have received a Copeland cementless surface replacement arthroplasty, the number of cases with a periprosthetic fracture is expected to increase.

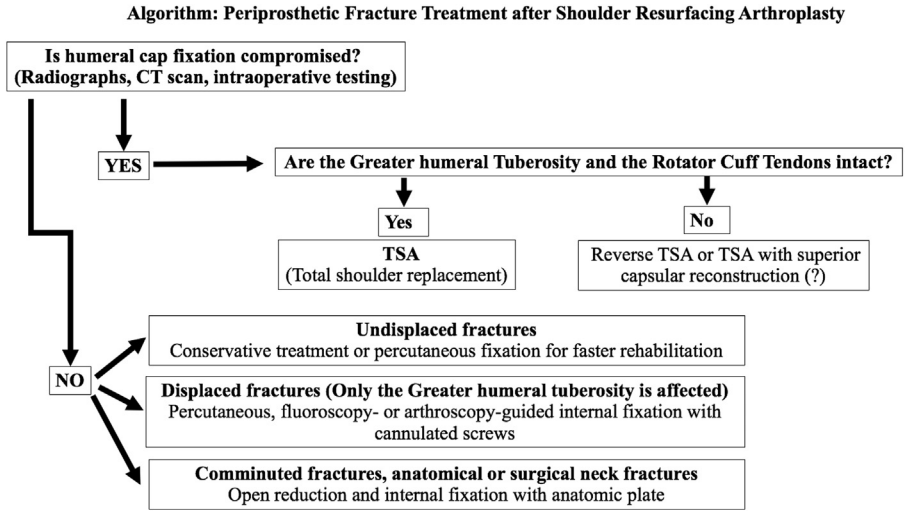

Figure 5 A proposed algorithm for the treatment of periprosthetic fractures after shoulder resurfacing arthroplasty.

However, shoulder revision surgery is a major operation with unknown long-term outcomes. When the implant is well fixed, retention of the implant is recommended. In patients with implant loosening, significant osteoporosis or humeral head comminution, revision surgery is the only option.

Following similar principles with the Copeland CSRA, hip resurfacing arthroplasty has also been described and used. In this resurfacing arthroplasty, any periprosthetic fracture can pose a clinical dilemma regarding its management as this can either be treated with revision arthroplasty or ORIF. Internal fixation of a periprosthetic hip fracture below a Birmingham Hip Resurfacing arthroplasty using a Dynamic Hip Screw (DePuy Synthes) and a cannulated screw has been reported in the literature with good results.[13]

In Figure 5, we present an algorithm for the treatment of periprosthetic fractures after shoulder resurfacing arthroplasty. The stability of the humeral cap is crucial as this will dictate whether ORIF or revision arthroplasty is warranted. A periprosthetic fracture leading to a compromise of the humeral cap fixation is going to require a revision arthroplasty in order to improve the patients shoulder function. The choice between an anatomic or a reverse total shoulder arthroplasty follows the same principles of a primary shoulder arthroplasty. The integrity of the rotator cuff has the most critical role in this decision. The presence of an intact rotator cuff and greater tuberosity will allow for an anatomical shoulder arthroplasty. The presence of a tear in the rotator cuff will lead to a reverse total shoulder arthroplasty, or an anatomical total shoulder arthroplasty with superior capsular reconstruction, if this is technically possible. If the humeral cap fixation is compromised, three possible management options can be selected depending on the displacement and comminution of the fracture. Nondisplaced fractures with a stable humeral cap can be managed conservatively or with percutaneous fixation, as they will not require reduction. Displaced fractures of the greater tuberosity can be fixed with percutaneous cannulated screws under fluoroscopic or arthroscopic guidance. Comminuted fractures or fractures of the anatomical or surgical neck will benefit from an ORIF with a proximal humeral plate, as in the case we have presented. This can achieve satisfactory reduction, stable fixation, and early rehabilitation, which can achieve excellent outcomes without the need for a revision arthroplasty.

In our case, the fixation of the periprosthetic fracture with a proximal humerus fracture plate managed to achieve healing of the fracture without the need to resort to revision of the prosthesis with excellent postoperative results. Fixation of the periprosthetic fractures around a Copeland cementless surface replacement arthroplasty can be a challenge, especially when retaining the prosthesis. The location of the fracture, the stability of the prosthesis, and the bone quality should guide the treatment choice.

In conclusion, Copeland CSRA is a fast, minimally traumatic operation that can restore normal shoulder anatomy and function. This operation can be a viable option in a large number of cases requiring shoulder arthroplasty, except from fracture reconstruction, where a stemmed prosthesis is required and rotator cuff arthropathy in the elderly, where reverse prosthesis provides better results.[8] If complications do occur, they can potentially be more easily treated.

The periprosthetic fractures are a common and devastating complication in stemmed shoulder prosthesis and require difficult and extended operations. On the contrary, periprosthetic fractures in Copeland Cementless surface replacement shoulder arthroplasty are extremely rare and even when they occur, the preservation of the natural shoulder anatomy and landmarks, the absence of cement, and the preservation of bone stock, allows them to be more easily managed during revision arthroplasty. Our case describes the first patient with a Copeland prosthesis, and a periprosthetic fracture that was treated with plate fixation and did not require a revision. This led to restoration of the shoulder function without a need for major revision arthroplasty.

Conclusion

We have demonstrated good results with the use of plate fixation as a treatment option in a patient with a periprosthetic proximal humerus fracture around a well-fixed Copeland CSRA prosthesis. Use of the Copeland CSRA allows anatomic resurfacing with conservation of bone stock, without creating a stress riser in the midshaft of the humerus and thus has lower periprosthetic fracture rates than in stemmed implants. When those fractures occur, they pose a significant clinical dilemma. We have suggested a treatment algorithm for the management of these fractures. It does seem that periprosthetic fractures around a well-fixed prosthesis can be effectively managed with ORIF without the need for revision arthroplasty.

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