ORIGINAL ARTICLE

Double Plating in Type C Distal Humerus Fractures: Current Treatment Options and Factors that Affect the Outcome

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Abstract

Purpose: This is a retrospective cohort study of type C distal humeral fractures (AO classification system) aimed at evaluating the effectiveness of current operative treatment options.

Materials and methods: Thirty-seven patients with type C distal humeral fractures, treated operatively from January 2002 to September 2016, were retrospectively studied. Thirty-two were eligible for inclusion. Patients were treated by open reduction using the posterior approach, olecranon osteotomy and parallel-plate two-column internal fixation. Patients were evaluated for fracture healing, functional outcomes and complications (infection, ulnar neuropathy, heterotopic ossification and need for implant removal). Restoration of the normal anatomy was defined by measuring carrying angle, posterior angulation and intercondylar distance of distal humerus.

Results: The mean follow-up time was 8.7 years [range 2–15.5 years, standard deviation (SD) = 3.96]. Mean time to fracture union was 8 weeks for 29 patients (90.6%) (range, 6–10 weeks). In nine cases, there was malunion of varied importance (28.1%). There was one case with postoperative ulnar neuropathy and one case with deep infection. The mean Disabilities of the Arm, Shoulder and Hand (DASH) score and mean Mayo Elbow Performance Score (MEPS) were 20 (range 0–49) and 83.3 (range 25–100), respectively.

Conclusion: In complex distal humerus fractures, the posterior approach with olecranon osteotomy and parallel plating of two columns, after anatomic reconstruction of the articular segment, is a prerequisite for successful elbow function.

Keywords: Distal humeral fractures, Double plating technique, Heterotopic ossification, Olecranon osteotomy, Tension band osteosynthesis, Two-column theory, Ulnar nerve management.

Strategies in Trauma and Limb Reconstruction (2022): 10.5005/jp-journals-10080-1546

Introduction

Distal humeral fractures represent 2% of adult elbow fractures and are, in the vast majority, the result of either high energy trauma in young patients or low energy trauma in the elderly with osteoporotic bone.[1] The low incidence and high complexity (the majority are AO type B and C) make for a demanding treatment issue.[2,3] These type C fractures include dissociation of distal humeral columns, but coexisting fractures of the proximal ulna and radius are not uncommon. Due to high-energy mechanism of injury, such fractures are often open or associated with soft tissue injury (abrasions, contusion) that increase difficulty in treatment.[3,4] Vascular and neurological evaluation of the injured upper extremity is important; distal humeral fractures are associated with vascular injuries which can lead to ischaemia demanding urgent treatment. Nerve injuries (mostly of the ulnar nerve) need surgical exploration.[4–9]

The diagnosis of this fracture is established by plain X-rays, but the radiographic evaluation alone is insufficient for preoperative planning. Computed tomography (CT) is used routinely for a thorough understanding of the morphology and complexity of distal humeral fractures. Two classification systems are used widely for distal humeral fractures. The AO or OTA classification describes the location and comminution better, while the Jupiter and Mehne classification focuses on the morphology of the fracture.[10,11]

Historically, conservative management with the 'treat as a bag of bones' technique was used, as proposed by Eastwood in 1937.[12] This treatment requires prolonged immobilisation leading to elbow stiffness and heterotopic ossification. A high percentage of unsatisfactory results after conservative treatment have been reported in the literature. Better results from operative treatment are now published, leading to advancement in surgical techniques and outcomes.[13–15] Immobilisation can be used only in cases of nondisplaced fractures or as temporary treatment before arthroplasty. Nonsurgical treatment can also be chosen as definitive in cases of neurologic deficit, advanced osteoporosis and fractures with extensive bone loss, where there is acceptance of an unsatisfactory final result.[3,16,17]

Surgical treatment is the contemporary treatment of choice.[18–21] The goal of treatment for distal humerus fractures is restoration of a stable, painless and functional elbow. The effectiveness of surgical treatment will depend on various factors. The elbow joint

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How to cite this article: Athanaselis ED, Komnos G, Deligeorgis D, *et al*. Double Plating in Type C Distal Humerus Fractures: Current Treatment Options and Factors that Affect the Outcome. Strategies Trauma Limb Reconstr 2022;17(1):7–13.

Source of support: Nil

Conflict of interest: None

is at risk of contractures and stiffness after both the initial injury and consequent surgical trauma. The surgical reconstruction of the distal humerus is often difficult due to its complex anatomy, fracture fragmentation and poor bone stock, especially in osteoporotic elderly patients. This requires a thorough understanding of 'fracture personality', knowledge of the available fixation techniques and available surgical skill. Evaluation of a patient's medical status and expectations are important.[22] Complications are associated with both the injury and surgical treatment and include nonunion, decreased elbow ROM (range of movement), implant failure, infection, ulnar nerve neuropathy, heterotopic ossification and post-traumatic arthritis. The operative outcome of distal humeral fractures can be unpredictable.[22,23] The aim of this study is to report the outcomes of a 15-year, single-centre experience of operatively treated type C distal humerus fractures.

Materials and Methods

This is a retrospective study of patients with a distal humeral fracture of AO type C treated with open reduction and internal fixation with two parallel plates. No ethical approval is required at our institution for retrospective studies. From January 2002 to September 2016, 37 patients with such a fracture were surgically treated in the orthopaedic department of a tertiary university hospital. This cohort was a consecutive series of patients with a type C humeral fracture. All had surgical management proposed for their fracture and were prepared and planned for surgery. Two patients were excluded due to a different modality of treatment [one total elbow arthroplasty (TEA) and one K-wire transfixation] carried out, while another one was considered as a high-risk patient and conservative treatment with elbow casting was chosen instead. Two other patients were lost in follow-up and were excluded as well. Descriptive statistics were used for the outcome variables.

Among the remaining 32 patients, 15 were males (47%) and 17 females (53%) with a mean age of 53.5 years (range 18–83). Right and left elbows were equally involved, and in 19 patients (59.4%), the dominant arm was injured. Three patients sustained open fractures (9.4%), two patients had an ipsilateral olecranon fracture, and one patient suffered from olecranon and radial head fracture. Mechanism of injury was simple fall in 22 patients (68.7%), a fall from a height in six cases (18.8%), and a motor vehicle accident in four cases (12.5%). Five patients sustained additional injuries.

The same operative technique was used by all senior surgeons in our department, with slight individual modifications. All had the posterior approach and olecranon osteotomy. Under general anaesthesia, the patient is positioned on the contralateral side with the affected arm hung across the chest allowing for elbow manipulation. A tourniquet was not used in order to achieve adequate access to the arm. The skin incision was placed posteriorly, curved slightly laterally in the middle, and the ulnar nerve is dissected for about 15–20 cm and protected throughout the operation.

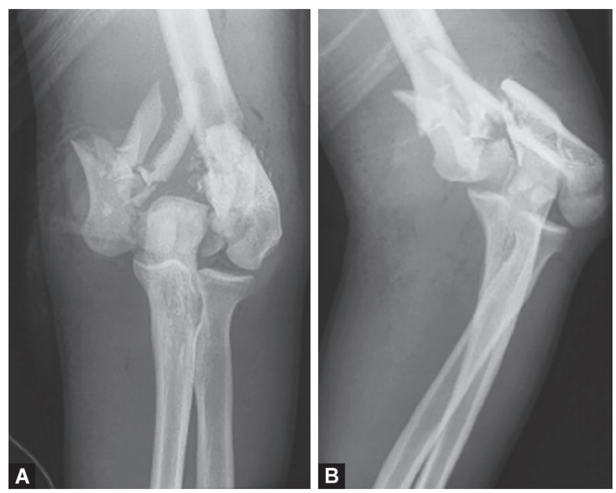
Early administration of antibiotics, debridement, meticulous irrigation by low-to-medium pressure lavage devices, and wound cultures were the standard of care for open fractures. Plates of various types and length but preferably pre-contoured locking plates positioned in parallel and were used to support the reconstructed medial and lateral columns, often combined with free screws and K-wires. The olecranon was fixed using a tension band technique in 26 patients and by other techniques (screw, plate) in six (including the two patients with the associated olecranon fracture). Immediate wound closure was possible in all cases. At the end of the procedure, unrestricted full range of elbow motion is verified, and the stability of fixation confirmed. The wound is closed in layers with a suction drain and bulky dressing placed (Figs 1 and 2). The elbow is splinted in flexion of 90° for 2 weeks for the inflammation to subside.

Postoperatively, a 90° back-slab was used for the first 3 weeks. Thereafter, patients' elbow mobilisation was started under dynamic splint protection until the sixth postoperative week. An individualised approach was used, and all patients were compliant with physiotherapy.

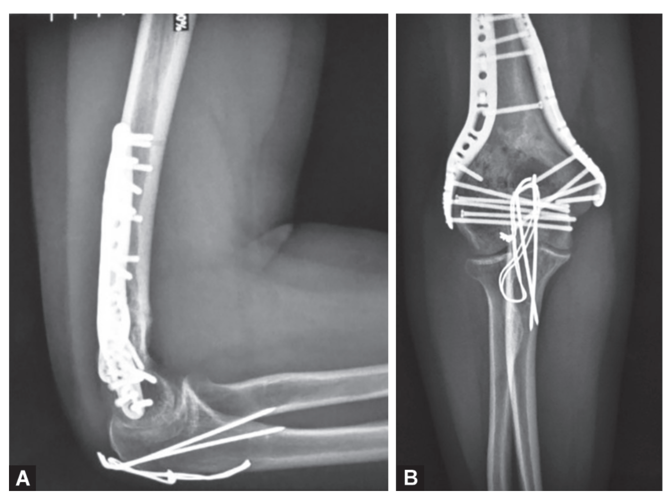
A clinical and radiological examination was carried out at 1, 2, 3 and 6 months after surgery and annually thereafter. The Disabilities of the Arm, Shoulder and Hand (DASH) score and Mayo Elbow Performance Score (MEPS) were utilised for evaluating the functional outcome. Both are widely used and considered reliable methods for elbow function outcomes after humeral fractures.[24,25] The mean follow-up time was 8.7 years (range 2–15.5 years, SD = 3.96).

Results

Twenty-nine patients (90.6%) had clinical and radiological signs of fracture healing by 57.2 days on average (range 44–72 days).



Figs 1A and B: Anteroposterior and lateral X-rays of distal humeral fracture of AO type C in a 50-year-old male



Figs 2A and B: Two-column internal osteosynthesis and tension band fixation of olecranon osteotomy 11 years postoperatively

Radiological signs of healing were declared when bone defects were filled along with a restoration of cortical continuity cortex on plain X-rays. No postoperative computed tomography (CT) scans were performed as this was not needed clinically. Two independent orthopaedic surgeons evaluated the radiographs (DD and MH). Clinical union was determined when the elbow joint was clinically stable, and there was no pain or restriction during motion.

Three patients (9.4%) were diagnosed with a nonunion. This occurred at the metaphyseal level in two cases and of the lateral condyle in one case. Local biological factors were considered the main reason for these complications. Infection was ruled out in all by preoperative aspiration (dry aspiration) and intraoperative cultures. All underwent revision osteosynthesis 6 months following the initial procedure using longer plates along with autograft from the iliac crest. In nine cases, there was malunion of varying importance (28.1%). Malunions were cases where minor radiological angulation and slight decrease of the range of motion were detected. However, these were classed of miscellaneous importance because there was no statistically significant decrease in the postoperative outcomes as measured through the scoring systems, and no patient neither complained of poor function nor requested further treatment. Correspondingly, this subgroup was not included as complications. Other postoperative complications included postoperative ulnar neuropathy (one patient), deep infection (one patient) and complex regional pain syndrome (CRPS, one patient). Ulnar nerve compression neuropathy was treated operatively with surgical decompression and neurolysis, whereas CRPS was treated by four sessions of regional injection of corticosteroids and lidocaine. Infection, diagnosed 17 months postoperatively, was treated by implant removal, surgical debridement and application of antibiotic beads for 5 days. No further osteosynthesis was needed as the fracture was considered healed. In total, the reoperation rate was 18.7% (six patients). Seven patients (21.9%) underwent surgical removal of the olecranon tension band within 18 months postoperatively due to implant failure (K-wires migration, wire breakage) and soft tissue tethering. A postoperative ulnar palsy was present in three patients (9.4%), but recovered spontaneously within 3 months. Heterotopic ossification was found in three patients, but it was of minor degree and insignificant in terms of elbow function.

Restoration of the normal anatomy was defined by measuring the carrying angle, posterior angulation and intercondylar distance of the distal humerus from radiographs. The average carrying angle was 8° (range 5–17°, SD = 2.97), and the average posterior angulation was 45° (range 40–56°, SD = 4.96). The intercondylar distance, as an indicator of joint width restoration (significant factor of elbow function), was found normal (100%) in 23 patients (72%) and decreased by an average 16.7% (5–25%) in nine patients in comparison with the contralateral elbow. Radiological findings of osteoarthritis (joint space narrowing, bone sclerosis and osteophytes) were present in half of the patients (16/32) in a mean time of 4.5 years (range 2.5–10 years), corresponding to the poorer functional results.

Elbow function was also evaluated and recorded. The average range of motion (ROM) was 117° (range 75–150°). An extension lag ranged from 0 to 45° (average 21°). Better function was observed in flexion with 141° in average (range 120–150°). The average pronation was 78.8° (range 60–90°) and supination 73.3° (range 70–90°). Patients were assessed with the DASH score (mean value 22.5, range 10–79) and MEPS (mean value 83.3, range 25–100) (Fig. 3).

Discussion

There is a variety of surgical treatment approaches for distal humeral fractures of AO type C internal fixation. Our approach of choice was a posterior skin incision curved at the level of the medial epicondyle to avoid contractures over ulnar nerve and followed by an olecranon osteotomy. A triceps-splitting exposure, paratricipital exposure (Alonso-Llames), triceps-sparing exposure (Bryan-Morrey) or triceps-reflecting anconeous pedicle are all possible options.[3,26–28] The advantages of triceps-sparing vs triceps-splitting approaches are of less blood loss, less scar formation and less muscle trauma in order to reduce the postoperative contracture and stiffness.[15,29,30] Trans-articular or extra-articular olecranon osteotomies are widely used. This is not a demanding technique and allows for satisfactory visualisation of the elbow joint. It is contraindicated in total elbow arthroplasty and precludes other approaches in the future. There are a few studies comparing triceps-splitting with olecranon osteotomy; most find no statistically significant differences in objective elbow strength, range of motion or functional outcomes. The re-operation rate in osteotomy for hardware removal due to implant complications ranged between 6 and 30% and olecranon nonunion rate ranged between 0 and 9%. However, nonunion after osteotomy is usually caused by inadequate fixation and thus can be prevented with stable fixation.[19,30–36] The evidence is stronger in support of the triceps-splitting approach when dealing with open fractures due to less disturbance of the blood supply.[15]

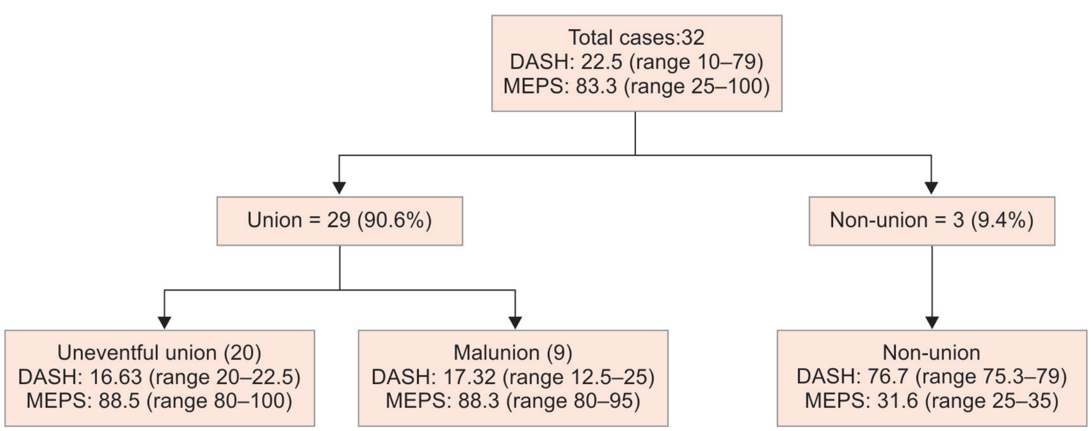


Fig. 3: Flowchart presenting cases according to union and outcome scores

We prefer an olecranon osteotomy using intra-articular chevron technique at the bare spot of the olecranon (centre of the olecranon sulcus), performed using an oscillating saw until the subchondral layer of bone is reached and finished by an osteotome, thereby avoiding thermal injury to cartilage. In cases of associated olecranon fracture, no osteotomy was needed. Olecranon osteosynthesis is carried out at the end by a tension band technique, intramedullary screw or new anatomical olecranon plates. We find the tension band as an effective, simple and low-cost solution, and this was used for the majority of our cases (81.25%). Precontoured plates were used in three patients including the two with olecranon fracture. Pitfalls in osteotomy osteosynthesis may arise from surgeon fatigue after a demanding and time-consuming surgical reconstruction of distal humerus. Care must be taken to avoid malreduction, unstable fixation and implant-related complications (e.g. pronation-supination inability due to K-wires or screws of inappropriate length or from anterior interosseous nerve irritation) (Fig. 4).

Internal fixation of distal humeral fractures must restore the anatomy to maximise functional recovery; this is from re-establishing congruency of the articular surface of the trochlea and capitellum, the intercondylar width and orientation of the condyles, despite fracture fragmentation.[3,21,37] Various plates with conventional or locking screws are available, but precontoured anatomical LCP plates have become a 'gold standard'.[38] After temporary stabilisation of bone fragments with K-wires (part of them can be left permanently in bone if needed), we prefer to use two precontoured locking plates to fix the medial and lateral columns. Plates must be of different lengths to avoid a stress-riser effect and risk of periprosthetic fracture. Locking plates are preferable as various locking screws inserted from both sides allow stabilisation of multiple intra-articular fragments, as well as stable fixation to the humeral shaft, with a lower incidence of loosening, especially in osteoporotic bone. Freehand application of screws is often inevitable to hold bone fragments in place and restore the articular surface. The distal humeral epiphysis triangle can be reconstructed first and then fixed en bloc to the shaft. The column with less comminution is attached first to restore length, although in cases of severe comminution and bone loss, supracondylar shortening maximises bone contact and improves stability. Bone defects must be replaced by bone graft, preferably autologous. This manner of osteosynthesis provides adequate stability to bending and rotational forces and permits early mobilisation of the elbow postoperatively.[15,30,39–42] Several randomised studies have shown that parallel (180°) placement of the two plates is biomechanically superior than perpendicular placement (90°). Posterior plating for the lateral column permits only for the insertion of short screws due to the small anteroposterior diameter of the humerus. Moreover, blood supply to the lateral column is mainly derived from posterior segmental vessels.[3,39,43–47] Sagittal plane plating reduces the risk of injuring these structures, improving the union rate, and it was the fixation method of choice in most of our cases except when fracture configuration did not allow for it.

Early mobilisation is vital to reduce stiffness, prevent heterotopic ossification and restore satisfactory function. Depending on the severity of comminution, the condition of soft tissue envelope and the stability of osteosynthesis, passive motion was started as soon as possible under protection of a dynamic splint. Elbow stiffness is the most common complication of distal humerus fractures. Joint incongruity, osteophytes, loose bodies, capsule adhesions and muscle contractures are common causes. Mild stiffness (<30°) can be treated by arthroscopic arthrolysis or limited open arthrolysis without hardware removal. Complex cases need open arthrolysis and hardware removal, or a total elbow arthroplasty (TEA).[3,48] Four patients (12.5%) underwent closed arthrolysis due to elbow stiffness. The ROM was 117° with greater restriction in extension. Unsatisfactory function was related to poor restoration of anatomy of the humeral epiphysis. Of those patients who needed tension band removal, extension was improved in four and pronation–supination in two. Long-term functional results became increasingly worse due to osteoarthritic changes with corresponding changes in the DASH and MEP scores (Fig. 5).

Nonunion (and malunion) of distal humeral fractures after ORIF is usually associated with implant failure. Nonunion can be located extra-articularly at the metaphyseal area of humerus or intra-articular. It ranges between 0 and 13% in published studies as a result of unstable fixation of severely comminuted fractures (high energy trauma), insufficient bone stock (osteoporosis), poor surgical technique or infection. Nonunions are treated with

Fig. 4: Tension band K-wires malpositioning or migration can cause soft tissue complications (e.g. skin irritation and anterior interosseous nerve pressure) leading to the necessity of implant removal surgery

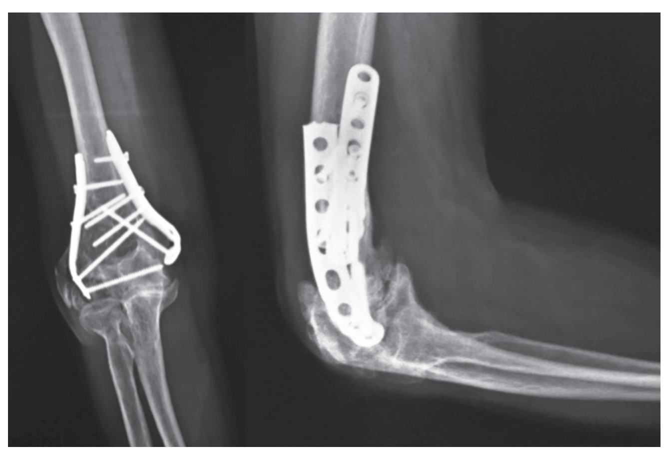


Fig. 5: Radiographic osteoarthritic findings (osteophytes, subchondral bone sclerosis, joint space narrowing) of a then 45-year-old female patient treated for intra-articular distal humeral fracture, 11 years postoperatively

revision surgery to improve stability and biology (with autografts) and are very challenging procedures ending up with external fixation or TEA.[3,19,48–54] In our series, there were three cases of nonunion (9.4%, located at the distal metaphysis and epiphysis of humerus) after 6-month follow-up which were treated with mechanical and biological augmentation. Plates were exchanged for longer ones and autograft from the iliac crest used in the nonunion site after meticulous debridement of fibrous tissue. There was no case of nonunion of the olecranon osteotomy. Good osteotomy technique and fixation are essential for preventing complications.[35,55]

An iatrogenic neurological injury is a common complication of internal fixation of distal humeral fractures. An ulnar nerve injury is perhaps one of the most common complications following surgical fixation (0–15%). Careful preoperative neurological evaluation of the upper limb, meticulous dissection of the nerve and proper positioning of implants can reduce the risk. There is an ongoing controversy over the need for anterior transposition of ulnar nerve. Existing evidence does not support its use routinely. However, some authors suggest it in patients with pre-existing symptoms of ulnar neuropathy.[6,49,56–59] In our series, the ulnar nerve was transposed anteriorly in a subcutaneous fat envelope created with absorbable sutures in order to be kept away from the implants of the medial column, preventing irritation during elbow flexion–extension. However, attention must be paid to avoid firm anterior positioning of ulnar nerve and stretching during elbow extension. Postoperative ulnar neuropathy was present in four of our patients (12.5%). In three (75%), intraoperative nerve compression by surgical instruments and excessive traction caused postoperative ulnar neurapraxia with mild disruption in sensation; all recovered spontaneously within 3 months. Ulnar compression neuropathy, if not a pre-existing condition (which can be difficult to define in injured patients), can be the result of implant impingement and scar tissue formation. Second-time decompression and neurolysis can be effective intervention in cases of post-traumatic and postoperative ulnar neuropathy and was used in one of our patients with persistent neurological findings 6 months postoperatively.[15,41,60–63]

Periarticular heterotopic ossification is a relatively common complication and adds to elbow stiffness and a poor functional result. The average published rate is 8.6% (range 0–21%) if no preventive treatment is used. High-energy open fractures, concomitant central nervous system injury, prolonged immobilisation and delay in surgical treatment are all recognised risk factors. Though published data are underpowered statistically to impose firm treatment recommendations, radiotherapy (e.g. one dose on the first postoperative day), indomethacin (e.g. 75 mg × 10–40 days) or both are treatment options.[49,56,64–66] Heterotopic ossification was present in three patients (9.4%) without impairing elbow function.

Deep infection ranges from 0 to 8% with increased incidence in open fractures, severe soft tissue injury and prolonged operation time. Implant removal, surgical debridement and antibiotic therapy (guided by tissue cultures) successfully eradicated deep infection in one of our patients (3.12%) that had healed 17 months postoperatively. If fracture had not healed, revision of ORIF or conversion to TEA is the proposed treatment choices as soon as infection is eradicated.[19,36,49,51,67]

This study is not without limitations. Despite the inherent flaws due to its retrospective nature, such as selection bias, data extraction from inadequate record keeping and no control group, this retrospective cohort study presents a wide variety of postoperative results, adding and expanding to what has already been published in recent literature.

Conclusion

The management of distal humeral fractures of AO type C is a challenging prospect that demands successful anatomic reconstruction for restoration of elbow function. The posterior approach with olecranon osteotomy allows a satisfactory exposure of the joint and preshaped locking compression plates achieve a stable fixation even in cases of excessive comminution. Early postoperative mobilisation is essential for prevention of elbow stiffness.

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