The Classic

Articular Replacement for the Humeral Head

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Abstract This Classic Article is a reprint of the original work by C.S. Neer, Articular Replacement for the Humeral Head. An accompanying biographical sketch of C.S. Neer is available at DOI [10.1007/s11999-011-1943-6](https://doi.org/10.1007/s11999-011-1943-6). The Classic Article is ©1955 and is reprinted with permission from The Journal of Bone and Joint Surgery from Neer CS. Articular Replacement for the Humeral Head. J Bone Joint Surg Am. 1955;37-A:215–228.

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This report presents a method of replacement of the proximal articular surface of the humerus.

In an earlier study the late results of twenty unimpacted fracture-dislocations treated by reduction, excision of the head, or arthrodesis were found unsatisfactory [6]. Reduction was followed by avascular necrosis, because the head was devoid of soft-tissue attachments. Arthrodesis failed because of the associated displacement of the tuberosities. Excision of the head with or without tendon transposition [3] resulted in a flail joint which lacked a fulcrum for abduction and rotation. After excision of the head, the *shoulder* remained uncomfortable and useless for many months until ankylosis through fibrous tissue and bone finally took place. Replacement by a prosthesis presented a logical solution. The initial prosthesis [6] had been designed for the treatment of these injuries.

During recent months seven patients with fracture-dislocations of the shoulder have been treated by replacement of the humeral head and repair of the avulsed tuberosities. In addition, the prosthesis has been used to replace irregular articular surfaces in five patients with old fractures of the humeral neck complicated by avascular necrosis.

Design of the Prosthesis

The integrity of the flat joint of the shoulder is dependent upon the short muscles, especially in this procedure, since the anterior half of the capsule is divided or excised at the time of replacement. The appliance is designed to replace the articular surface only and the anatomy of the tuberosities and their attachments is disturbed as little as possible.

The articular portion of the prosthesis is formed in the shape of a normal humeral head, with the exception of the superior surface. The superior edge is flattened to permit seating of the prosthesis into the greater tuberosity, so that impingement under the acromion is prevented. The edges are lipped all the way around, so that they can be set into bone. The original prosthesis has been modified to include a three-flange mechanism at the neck which adds fixation and eliminates rotation. A hole is placed in the neck so that the fragments of the tuberosity are held together and to the prosthesis in fresh fracture-dislocations [6] (Fig. 1). The stem diffuses strain over a fifteen-centimeter span. Measurements of seventy-five humeri indicated that the medullary cavities vary in diameter from 0.4 to 2.2 centimeters. An attempt to select one thickness suitable for all cases proved unsatisfactory and the prostheses are now

Fig. 1 Photographs of the replacement prosthesis. The small, medium, and large models are shown in side, front, and back views, respectively.

being constructed with three stem sizes (Fig. 1). It is not necessary to have different appliances for the right and left sides; however, the surgeon must remember that *the normal humeral head faces posteriorly about 20 degrees*. The proper amount of retroversion can be readily selected if the two epicondyles are palpated at the elbow and the head is turned about 20 degrees from their plane.

Vitallium is used for construction of the prosthesis, since it is believed that an inert metal of this type is superior to non-metallic material. The weight has not proved a handicap.

Technique

A stem of the proper size should be selected before the operation. The correct size can be determined by taping the appliance to the lateral surface of the arm in the plane it is to occupy and making an anteroposterior roentgenogram. The small, medium, and large prostheses may in turn be measured against the medullary canal in this manner.

The operation is performed with the patient in the "barber-chair" position, the head and knees being raised 30 degrees. The incision is made lateral to the coracoid over the deltopectoral interval, beginning at the clavicle and passing downward 12.5 centimeters. The deltopectoral route is preferred to the transacromial, because the latter results in the problem of a weakened deltoid after operation. The approach should be accomplished with minimum disturbance of muscles and their attachments. The cephalic

vein is ligated and removed. The anterior portion of the deltoid is reflected from the clavicle by sharp dissection, enough tissue being left upon the clavicle for reattachment. Thus the deltoid is mobilized laterally sufficiently so that the upper portion of the humerus is seen. The arm is placed in full external rotation, so that the subscapularis tendon is brought into view; this is secured with a stay suture and is then divided from the lesser tuberosity. If a fracture of the lesser tuberosity is present (as in fracture-dislocations) the division of the subscapularis is unnecessary and in such cases the biceps tendon acts as a guide. The capsule is opened transversely. Capsular division and excision must be extensive enough to permit dislocation of the head. In cases of old fracture, the anterior half of the capsule should be divided. The head is placed into the incision by external rotation and prying with a blunt elevator; this brings the entire articular surface into view. The articulating dome is excised with a broad osteotome. The biceps tendon is detached from the glenoid and is drawn out from its groove. The center of the medullary cavity is found by making a small opening through the cancellous bone in the neck and probing. This opening is enlarged to the size of the stem, so that the neck is prepared to receive the prosthesis and three thin osteotomy cuts are made in the cancellous bone for the three flanges. The prosthesis can then be pushed half-way in by hand, after which the set for the Judet appliance [4] is used to seat the device completely. Before final seating, the rotatory position of the head is checked by palpation of the epicondyles. If the head lacks the normal 20 degrees of retroversion, there may be

a tendency toward anterior subluxation. The bone along the neck can be trimmed to proper shape just before the prosthesis is seated.

Recent fracture-dislocations are a special problem. These lesions consistently follow a four-fragment pattern [1, 3, 6]: (1) the detached head, extracapsular and often rotated as much as 180 degrees; (2) the greater tuberosity, retracted posteriorly by the external rotators; (3) the lesser tuberosity, pulled medially by the subscapularis tendon; and (4) the shaft. A hole is present in the neck of the appliance, so that the tuberosities can be secured to the prosthesis as they are approximated (Fig. 2B).

Closure should include reattachment of the subscapularis, suture of the biceps, and repair of the detached portion of the deltoid. If the capsule is thickened and shortened, as in all old cases, no attempt is made to repair it. The deltoid and pectoralis fall together and the skin is closed loosely.

After operation the arm is placed in a sling and swathe. Pendulum exercises are begun after forty-eight hours and progressive flexion movements, such as overhead pulley exercising and "wall climbing", are started as soon as the patient can tolerate them. The arm is allowed complete freedom during the daytime from the fourth day. It is bound with a sling and swathe or with a wrist-trunk strap at night for the first three weeks. External rotation and abduction exercises cannot be permitted until the subscapularis has become reattached, usually at the third week.

The importance of this exercise regimen is explained to the patient before operation.

Analysis of Cases

Twelve replacements of the proximal humeral articulation, according to the method described, were done between January 1953 and April 1954 in the New York Orthopaedic-Columbia-Presbyterian Medical Center.

CASE I. T. M., a female, aged fifty-four years, had sustained a fracture of the neck of the left humerus thirty-three months prior to admission. This had resulted in avascular necrosis of the humeral head (Fig. 3A). Pain persisted in spite of months of treatment under the direction of a physical therapist and an orthopaedic surgeon. The patient was strongly left-handed and was unable to hang out clothes or set her hair. Night pain was particularly intense. Examination revealed 10 degrees of painful glenohumeral motion, with a fixed internal-rotation deformity of 20 degrees.

The replacement operation was performed on January 26, 1953. On the day following the operation the patient remarked that "the old pain is now gone". Within ten days after operation she had regained 90 percent, of shoulder flexion (Fig. 3C). She resumed her duties as a housewife three weeks after operation and has been free of pain.

ARTICULAR REPLACEMENT FOR THE HUMERAL HEAD

Fig. 2A–B (A) Drawing of a typical fracture-dislocation. The head is detached and lies outside the capsule, the greater tuberosity is pulled backward by the external rotators, and the lesser tuberosity is

displaced medially by the subscapularis. (B) The wire-loop repair, which holds the fragments together, is illustrated.

Fig. 3A–E (A) Case 1. The preoperative roentgenogram showed segmental necrosis three years after non-operative treatment of a fracture of the surgical neck of the humerus. (B) Photograph showing the irregular articular surface and loose body removed at operation. (C) Photograph showing active elevation eleven days after insertion of the prosthesis. The patient was free from pain. (D) Roentgenograms made four months after operation, with the arm at the side and overhead. (E) Photographs made twenty-three months after the replacement procedure.

Examination twenty-three months after operation indicated a full range of internal rotation, external rotation, and extension. There was loss of flexion of 10 degrees and limitation of abduction of 25 degrees. The site of malunion of the tuberosity had not been disturbed at the time of replacement and this presumably restricted abduction. Strength was excellent and the patient was using the arm for the same activities as before injury. She had no pain and slept well. Roentgenograms indicated good position and absence of resorption.

CASE 2. G. A., a male, aged forty-four years, was admitted three months after he had sustained a posterior dislocation of the shoulder with a fracture of the humeral neck. The fracture-dislocation was unreduced and the arm was fixed in internal rotation of 50 degrees. No definite glenohumeral movement could be elicited. The pain was so intense that the patient could not sleep and was completely incapacitated for his job as a waiter.

The replacement procedure was performed on March 18, 1953. The anterior half of the humeral head was found to be crushed into the tuberosities and the posterior half was rotated extra-articularly and united to the posterior aspect of the glenoid labium by fibrous tissue and bone (Fig. 4A). The replacement prosthesis filled the joint space

sufficiently so that no tendency to posterior luxation existed after its insertion. Immediate relief of pain was obtained.

Three months after operation, the patient returned to regular work in a prominent restaurant, carrying heavy overhead trays. Examination ten months after operation revealed excellent strength. He had no pain. The internal-rotation deformity was no longer present and he had external rotation to the neutral position. Glenohumeral abduction and flexion were limited to 25 degrees. Roentgenograms revealed ossification in the posterior capsule at the site of the initial malunion. It was believed that this was responsible for the limitation of motion. The patient was pleased with his result and did not desire further surgery.

CASE 3. L.G., a female, aged thirty-nine years, was admitted one year after a fracture-dislocation of the left shoulder. An open reduction had been performed in another hospital and avascular necrosis and collapse of the humeral head had apparently resulted. Pain and crepitation were pronounced.

A replacement operation was performed on April 17, 1953, and the relief of pain was striking. Roentgenograms made after operation revealed incomplete seating of the prosthesis. However, the patient required no analgesia after

Fig. 3A–E continued

the initial twenty-four-hour period. She was discharged from the Hospital on the fifth day after operation.

At examination fourteen months after operation the patient was working as a housewife. The range of motion in the shoulder was as follows: flexion to 155 degrees, abduction to 135 degrees, extension to 35 degrees, and full internal and external rotation as compared with the normal side. The patient was pleased with the range of movement, but stated that she had considerable discomfort in the shoulder after use. Roentgenograms indicated no change in the position of the prosthesis (Fig. 5B). It occupied the same cephalad position as before operation. There was no resorption.

CASE 4. J. S., a female, aged fifty-two years, was admitted twelve months following an unimpacted fracture of the humeral neck of the left shoulder. Roentgenograms indicated that the articular surface of the head was lying free within the joint as a loose body (Fig. 6A). To complicate the problem, this patient had undergone partial scapulectomy six years previously; this had resulted in a 60 per cent, reduction of scapulothoracic motion. There was severe restriction of glenohumeral movement and it was impossible for her to reach her mouth, chest, or buttocks. Pain was marked.

Articular replacement was performed on April 30, 1953. Full passive glenohumeral motion was present at the

conclusion of the procedure. The patient was able to reach her mouth and button her clothing for the first time in months. Roentgenographic studies made after operation revealed the prosthesis to be subluxated inferiorly, but roentgenograms made twelve days later indicated normal position. The patient returned to her regular duties as a housewife after two weeks. She sustained an ankle fracture

Fig. 6A–D (A) Case 4. Preoperative roentgenograms showing the original fracture. (B) Roentgenogram made twelve months later, showing segmental necrosis of the head. (C) Roentgenograms, made with the arm at the side and with the arm actively abducted, showing the range of motion twelve months after the replacement procedure. (D) Photographs made twenty months after the replacement procedure. The patient has excellent function, in spite of an old partial scapulectomy.

Fig. 4A–B Case 2. Illustrating pericapsular ossification following late repair of a neglected fracture-dislocation. (A) Preoperative roentgenogram showing the posterior fracture-dislocation three

months after injury. (B) Roentgenogram showing ossification posteriorly following replacement. This suggests the need of immediate treatment when extracapsular damage is present.

Fig. 5A–B Case 3. Illustrating improper seating of the prosthesis. (A) Preoperative roentgenogram, showing avascular necrosis one year after open reduction. (B) The position of the prosthesis, which had not

been seated properly, remained unchanged fourteen months after operation. This patient's shoulder was painful after use.

A

B

C

D

Fig. 7A–E (A) Case 7. This patient sustained an “impression fracture”, with posterior luxation of the head and distortion of more than half of the articular surface. These lesions are usually produced by electroshock therapy, as was the case in this patient. (B) Roentgenogram made seven days after operation, showing temporary subluxation. (C) Roentgenogram made twelve days later, showing

restoration of the normal position as muscle tone had been regained. (D) Roentgenogram made twenty months after the replacement procedure, with the arm at the side and overhead. (E) Photographs, made twelve months after the replacement operation, showing the patient with the arms in external rotation, internal rotation, and abduction. The strength in both arms was good.

four months later and for a period of twelve weeks used crutches without difficulty.

At examination twenty months after operation there was full range of glenohumeral motion (Fig. 6D). Strength was excellent. The patient had no pain. She used her arm for all housework without difficulties. Roentgenographic studies revealed no absorption about the prosthesis.

CASE 5. A. L., a male, aged sixty-seven years, sustained a comminuted, unimpacted fracture of the left humeral neck on June 18, 1953. The fracture was exposed twelve hours after injury and the head fragment was found to be devoid of soft-part attachments. The replacement procedure was performed and the two tuberosities were reduced

and fixed together and to the prosthesis. The patient was discharged from the Hospital twelve days later with detailed instructions in exercises. He returned to regular work as a clerk two and a half months after operation, at which time roentgenographic studies revealed bony union between the tuberosities and the shaft.

At examination eighteen months following operation, he had good strength and no pain except for an occasional mild weather ache. He could flex to 145 degrees, abduct to 150 degrees, and extend to 20 degrees; external rotation was to 15 degrees, and internal rotation was the same as in the normal side. Roentgenographic studies indicated firm seating of the prosthesis. He was working at his regular job as a mail clerk.

Fig. 7A–E continued

CASE 6. G. H., a housewife, aged sixty-six years, sustained a fracture-dislocation of the right shoulder in July 1953. She was admitted to the New York Orthopaedic-Columbia-Presbyterian Medical Center in November 1953, at which time it was discovered that the humeral head was still lying outside the capsule and was rotated 60 degrees. The anterior rim of the glenoid fossa had been fractured coincidentally. There was no detectable shoulder motion. Operation on November 17, 1953, consisted of replacement of the humeral head and stapling of the capsule to the anterior aspect of the glenoid rim. The patient required no medication for pain after the fifth day.

At examination six months after operation the patient had no pain and was performing her duties as a housewife. Extensive repair tissue had been encountered at the time of replacement; this probably accounted for the fact that glenohumeral motion was limited to about 20 per cent, of

normal at the time of this examination. Roentgenograms indicated good position of the prosthesis.

CASE 7. A. O., a female, aged forty-four years, entered the Hospital in November 1953, having sustained a posterior fracture-dislocation of the right shoulder while receiving electroshock therapy two weeks previously. The arm was fixed in full internal rotation. Closed reduction attempted under general anaesthesia had failed.

On December 3, 1953, it was noted after open reduction that a severe "impression" fracture was present, the anterior 60 per cent, of the articular surface of the humerus having been crushed into the tuberosities (Fig. 7A). This defect in the head caused the shoulder to dislocate when the arm was brought to neutral rotation. A small-stem prosthesis was inserted and this filled the joint sufficiently to restore stability. The arm was placed in balanced suspension for the first seven days after operation. A temporary

Fig. 8A–C (A) Case 10. Preoperative roentgenogram of a typical anterior fracture-dislocation, showing the head detached and lying outside the capsule. (B) Roentgenogram made two months after wire-loop repair, showing the tuberosities uniting to the shaft. In more

recent cases a finer wire has been used and it has been carefully buried in the tendons. (C) Photographs, made ten months after wire-loop repair, showed only fair recovery of motion. However, the patient was free pain.

subluxation was then noted (Fig. 7B). The patient returned to her regular duties as a nurse six weeks later.

At examination twelve months after operation there was no pain. Excessive lifting of patients caused shoulder fatigue; however, she was nursing without handicap. The range of motion in the shoulder was: flexion to 160 degrees, abduction to 160 degrees, extension to 30 degrees, and full internal and external rotation as compared with the normal side (Fig. 7C). Roentgenographic studies indicated absence of reaction and good position. The patient was pleased with the result.

CASE 8. T. M., a female, aged sixty-five years, presented an untreated anterior fracture-dislocation of the shoulder of one month's duration. Closed reduction was attempted and failed. On January 28, 1954, an open reduction was performed, at which time it was discovered that the articular

cartilage was lifted from the head, exposing three quarters of the underlying cancellous bone. The lesser tuberosity of the humerus and the anterior rim of the glenoid fossa were fractured and displaced into a mass of repair tissue. A prosthesis was used to replace the head and the anterior capsule was fixed to the glenoid rim with a staple. Pendulum exercises were begun one week later, at which time the patient had almost no pain. She was discharged from the Hospital three weeks after operation.

This patient refused to return for outpatient treatment because she did not have time. A report from her family physician three months after operation indicated that the patient was doing her regular work as a building superintendent and that she had no complaints. He was unable to describe the range of motion but thought it was satisfactory.

Fig. 9A–C (A, B) Case 12. Preoperative anteroposterior and axillary roentgenograms of a posterior fracture-dislocation. The head was rotated 90 degrees. (C) Postoperative roentgenogram illustrating the repair.

CASE 9. F. A., a male, aged sixty-one years, presented a badly disorganized posterior fracture-dislocation of the right shoulder of five weeks' duration. The intra-articular portion of the humerus was broken into many pieces, the largest of which was extruded posteriorly, and fractures of both tuberosities had healed with displacement. On February 16, 1954, the joint was exposed from the front and, after removal of the head fragments, the prosthesis was inserted.

This patient, a physician, returned to his home in South America one month after operation and has not been seen since. He referred a patient, Case 12, to this Hospital two months later with a similar injury, who reported that the physician was doing well.

CASE 10. B. D., a male, fifty-four years old, sustained a typical four-fragment anterior fracture-dislocation of the right shoulder on February 24, 1954 (Fig. 8A). The reconstruction operation was performed twenty-four hours after injury. The head was lying outside the joint and was detached from the soft parts, except for a thin strand of ligament. The greater and lesser tuberosities were displaced by the external rotators and subscapularis tendons. The head was removed and was replaced with the large-stem prosthesis. The tuberosities were approximated as shown in Fig. 2B. Roentgenograms made after operation indicated a tendency for the prosthesis to sublunate anteriorly, but, as

exercises were continued and muscles regained tone, this tendency disappeared. The patient returned to his work as an artist five weeks after operation, at which time he had no pain. Roentgenographs studies made six weeks after operation showed bridging callus between the tuberosities and the shaft.

The patient returned two months after operation complaining of pain and fever. Examination revealed an area of fluctuation under the operative scar. He was readmitted and a superficial abscess was drained. Cultures revealed hemolytic *Staphylococcus aureus* sensitive to all antibiotics. Treatment with terramycin was begun. Three weeks later the wound had closed and the patient resumed his work and his program of exercise. The infection was superficial to the prosthesis and it was not necessary to remove the appliance. The patient had resumed work and was free of pain ten months later (Fig. 8C).

CASE 11. I. S., a female, aged seventy years, entered the Hospital after one year of unsuccessful non-operative treatment for a painful, stiff left shoulder. Roentgenograms revealed the marginal osteophytes and thinning of the joint space characteristic of osteoarthritis. There had been an injury three years previously, which suggested a traumatic basis for the degeneration. Glenohumeral motion was restricted to about 20 degrees and the movement was accompanied by marked crepitus and pain.

Table 1. Summary of cases

Case No. Initials	Age (Years)	Occupation	Preoperative condition	Duration of symptoms	Operative repair	Follow-up (months)	Result pain	Range of motion
1. T.M.	54	Housewife	Avascular necrosis	33 mos.	Tuberosities not disturbed	23	None	Good
2. G.A.	44	Waiter	Fracture-dislocation (posterior)	3 mos.	Tuberosities not disturbed	10	None	Poor
3. L.G.	39	Housewife	Avascular necrosis	15 mos.	Tuberosities not disturbed	14	With use	Good
4. J.S.	52	Housewife	Avascular necrosis	1 yr.	Tuberosities not disturbed	20	None	Excellent
5. A.L.	67	Mail clerk	Fracture-dislocation (anterior)	12 hrs.	Wire-loop repair	18	None	Good
6. G.H.	66	Housewife	Fracture-dislocation (anterior)	3½ mos.	Wire-loop repair and stapling	6	None	Poor
7. A.O.	44	Nurse	“Impression fracture” Fracture-dislocation (posterior)	3 wks.	Tuberosities not disturbed	12	None	Good
8. T.M.	65	Building superintendent	Fracture-dislocation (anterior)	1 mo.	Stapling. Tuberosities not disturbed	3	“Satisfactory”	
9. F.A.	61	Physician	Fracture-dislocation (posterior)	1 mo.	Tuberosities not disturbed	3	“Satisfactory”	
10. B.D.	54	Painter	Fracture-dislocation (anterior)	24 hrs.	Wire-loop repair	8	None	Fair
11. I.S.	70	Housewife	Hypertrophic osteoarthritis	3 yrs.	Tuberosities not disturbed	7	None	?
12. G.L.	46	Housewife	Fracture-dislocation (posterior)	8 days	Wire-loop repair	2	None	?

On March 16, 1954, the joint was explored; a humeral head with irregular contours and almost devoid of articular cartilage was revealed. Under anaesthesia it was impossible to move the glenohumeral joint to more than 20 degrees of abduction. The articulating dome was removed and, after insertion of the prosthesis, it was possible to move the shoulder through a full range of motion. Thirty-six hours after operation the patient remarked that she had less pain than before the operation. She returned to her home in the Middle West ten days after operation.

She has not been examined since that date. However, she informed us by letter seven months later that she was free of pain and “leading a new life”.

CASE 12. G. L., a female, aged forty-six years, was admitted to the Hospital with a comminuted posterior fracture-dislocation of eight days' duration. On April 23, 1954, a replacement operation was performed and the disrupted tuberosities were reduced and fixed to the prosthesis (Fig. 9C). After operation the arm was placed in balanced suspension for fourteen days. Initially there was a temporary tendency for the prosthesis to sublunate

interiorly. The patient was free from pain when she was discharged from the Hospital twenty-eight days after operation.

At examination eight weeks after surgery the patient could abduct to 120 degrees and flex to 160 degrees. She had no pain. She returned to her home in South America at that time.

Each of these patients had been suffering from either a recent extra-articular extrusion and detachment of the humeral head or a long-standing painful incongruity of the humeral articulation. In the latter situation conservative treatment had been tried and had failed in every instance. The replacement procedure was followed by a remarkably pain-free convalescence. The stiffness present in Case 2 and Case 6 (Table 1) suggests the need of early reconstruction of extra-articular lesions before extensive repair occurs. A tendency toward inferior subluxation of the prosthesis was observed after operation in four patients, but this disappeared as soon as muscle tone had been regained. There were no other complications, with the exception of the superficial wound infection in Case 10. There have

been no dislocations. Eleven of the twelve patients are free from pain, the one instance of improper seating of the prosthesis, Case 3, being the exception. None of these patients require further operative treatment.

Discussion

The literature contains many references to the soft-part structures of the shoulder joint, but little attention has been given to the articulating surface. Glenohumeral motion is dependent upon the fulcrum action of the humeral head and, contrary to previous belief [2, 3, 5], excision of the humeral head does not result in acceptable function [6]. So far, results of the operation described have been found to be superior to those of head resection. An arthrodesis of this joint requires a long time to consolidate and is particularly difficult and uncertain if it is performed upon necrotic bone or a fresh fracture. Properly performed, articular replacement is followed by a relatively short and asymptomatic convalescence. Although there has been insufficient time for adequate follow-up, it is logical to

assume that a prosthesis would wear better in this non-weight-bearing joint than in the hip.

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