Original Article

Primary total elbow arthroplasty

Suresh Kumar, Sunayan Mahanta

Abstract

Background: Primary total elbow arthroplasty (TEA) is a challenging procedure for orthopedic surgeons. It is not performed as frequently as compared to hip or knee arthroplasty. The elbow is a nonweight-bearing joint; however, static loading can create forces up to three times the body weight and dynamic loading up to six times. For elderly patients with deformity and ankylosis of the elbow due to posttraumatic arthritis or rheumatoid arthritis or comminuted fracture distal humerus, arthroplasty is one of the option. The aim of this study is to analyze the role of primary total elbow arthroplasty in cases of crippling deformity of elbow.

Materials and Methods: We analyzed 11 cases of TEA, between December 2002 and September 2012. There were 8 females and 3 males. The average age was 40 years (range 30-69 years). The indications for TEA were rheumatoid arthritis, comminuted fracture distal humerus with intraarticular extension, and posttraumatic bony ankylosis of elbow joint. The Baksi sloppy (semi constrained) hinge elbow prosthesis was used. Clinico-radiological followup was done at 1 month, 3 months, 6 months, 1 year, and then yearly basis.

Results: In the present study, average supination was 70° (range 60-80°) and average pronation was 70° (range 60-80°). Average flexion was 135° (range 130-135°). However, in 5 cases, there was loss of 15 to 35° (average 25°) of extension (45°) out of 11 cases. The mean Mayo elbow performance score was 95.4 points (range 70-100). Arm length discrepancy was only in four patients which was 36% out of 11 cases. Clinico-radiologically all the elbows were stable except in one case and no immediate postoperative complication was noted. Radiolucency or loosening of ulnar stem was seen in 2 cases (18%) out of 11 cases, in 1 case it was noted after 5 years and in another after 10 years. In second case, revision arthroplasty was done, in which only ulnar hinge section, hinge screw and lock screw with hexagonal head were replaced.

Conclusion: Elbow arthroplasty remains a valuable option for deformed and ankylosed elbows especially in the demanding patients with crippling deformity of the elbow.

Key words: Ankylosis, comminuted fracture of distal humerus, total elbow arthroplasty

Introduction

Joints play an important role for the routine activities whether they are weight bearing or nonweight bearing. The elbow is a nonweight bearing joint; however, static loading can create forces up to three times the body weight and dynamic loading up to six times.[1,2] Elbow joint movement is essential to co-ordinate shoulder as well as wrist joint movements and also helpful in performing the activities of daily living like eating, combing, writing, lifting weights, personal hygiene, etc., When the anatomy of the elbow joint is distorted by comminuted fracture of distal humerus with intraarticular extension, rheumatoid arthritis or secondary arthritis, post burn ankylosis or posttraumatic ankylosis, it may result in crippling deformity which hampers the activities of daily living. For such cases, primary total elbow arthroplasty (TEA) is the answer.

In general, elbow arthroplasty is less frequently performed as compared to hip or knee arthroplasty.[3] It may be due to the higher incidence of complications like implant loosening due to cyclic loading in flexion and extension causing compressive and distractive load directed anteriorly, superiorly, and posterior.[4] However, during the last 10 to 15 years, there has been a marked improvement in implant survival and a considerable decrease in the rate of complications due to better implant designs.[5-10] Moreover, TEA procedure should be done by surgeons having experience in this surgical technique. Proper selection of patients is also very important like avoid arthroplasty in manual laborers, weight lifters, sport persons, etc.

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There is still limited information about the long term effectiveness of converting an ankylosed elbow to elbow arthroplasty,[11,12] still arthroplasty may be the choice of treatment in the elderly patients with crippled deformity of elbow due to non reconstructable fracture of distal humerus and also in cases of ankylosis of elbow joint in nonfunctional position due to rheumatoid arthritis or secondary arthritis.[13] In young patients, non reconstructable intraarticular distal humerus fracture or distorted elbow due to rheumatoid arthritis or other causes, one may go for primary TEA after discussing the pros and cons of the procedure with the patient, provided he or she has a low demanding job. Interposition elbow arthroplasty used to be a salvage procedure in young patients with inflammatory arthritis or posttraumatic arthritis, as it completely neither eliminates pain nor restores full function.[14] However, due to improved implant design, elbow arthroplasty may achieve a painless, stable, and mobile joint.

This study evaluates the outcome of elbow arthroplasty.

Materials and Methods

11 patients of primary TEA operated between December 2002 and September 2012 were included in this study. There were 8 females and 3 males. The mean age was 40 years (range 30-69 years). Baksi's sloppy (semi constrained) hinge elbow prosthesis was used. The indications for TEA were rheumatoid arthritis, comminuted fracture distal humerus with intraarticular extension, and posttraumatic bony ankylosis of elbow joint. Patients with compound fracture around elbow, severely comminuted fracture proximal ulna, flaccid paralysis of the upper limb, nonrestorable function of biceps or triceps and patients with high demanding jobs have been excluded from the study. Pre-operative clinico-radiological assessment was done.

Out of eight female patients, three had rheumatoid arthritis [Figure 1] and three had ankylosis in about 90 degree flexion (one had post burn ankylosis of elbow with about 90 degree of flexion [Figure 2]), two had post traumatic arthritis with ankylosis in 80 degree of flexion [Figure 3] and two cases were of fracture: One had nonunion of distal humerus with deformed ulno-humeral joint with osteoporosis and the other had malunited fracture distal humerus with nonunion fracture proximal ulna with implant failure [Figure 4]. Out of the three male patients, one had posttraumatic bony ankylosis of the elbow joint and the other two had severely comminuted intraarticular fracture of distal humerus.

Operative procedure

All the surgeries were performed in lateral decubitus position. Under regional or general anesthesia and tourniquet, parts were cleaned and draped. Incision was made posterior midline slightly curved over the tip of olecranon on the medial side extending from the distal arm downwards over the proximal part of ulna. The ulnar nerve was identified, mobilized, and transposed anteriorly, submuscularly to avoid stretching and irritation by hardware. In the initial five cases, we used a tongue-shaped flap of the triceps attached to the tip of the olecranon and then reflected it downward, but later on we started mobilizing the triceps laterally as a continuous sleeve. The main purpose was to maintain the extensor mechanism of elbow joint, but we did not find much significant difference. Distal end of humerus was exposed along with its epicondyles extraperiosteally by detaching all the muscles around it. Elbow joint opened, synovectomy carried out followed by radial head excision. Humeral cut was made at the superior surface of olecranon fossa with the oscillating saw. Subarticular L-shaped cut was made at the proximal part of ulna preserving the insertions of triceps at olecranon process and brachialis at coronoid process. The bony mass was then removed [Figure 1b].

Reaming of medullary canal of distal humerus was done with triangular humeral reamer and upper part of ulna with quadrangular rasp and harpoon shaped reamer and wound lavage done with a pulse lavage system. The vertical height of the prosthetic hinge was compared with the gap between the cut ends of the humerus and the ulna in both, extension and flexion. It may be necessary, to resect more bone from the distal humerus to accommodate the hinge, in patients with marked contractures of the flexors and extensors. Trial reduction was done and then the final ulnar and humeral components were fixed to the bone with manual technique of bone cementing. The humeral and ulnar hinged section were assembled with hinge screw and then secured with a lock screw [Figure 1c].

The range of movement of the elbow checked passively peroperatively, hemostasis achieved after tourniquet release, triceps repair done, and wound closed in layers over a suction drain. A POP back slab was applied with elbow in 90 degree of flexion and forearm in supination, as it is the functional position and is comfortable to the patient. We routinely mobilize the elbow after 48 hours.

Postoperatively the drain was removed after 48 hours of surgery. Intermittent active or passive movements of the elbow out of the slab encouraged. Stitches were removed 12 days after surgery and removable splint was discontinued at 6 weeks. Patients were advised to avoid lifting heavy objects and strenuous activity.

Results

Primary TEA was done as a definitive procedure in elderly patients and in selected cases in younger patients.

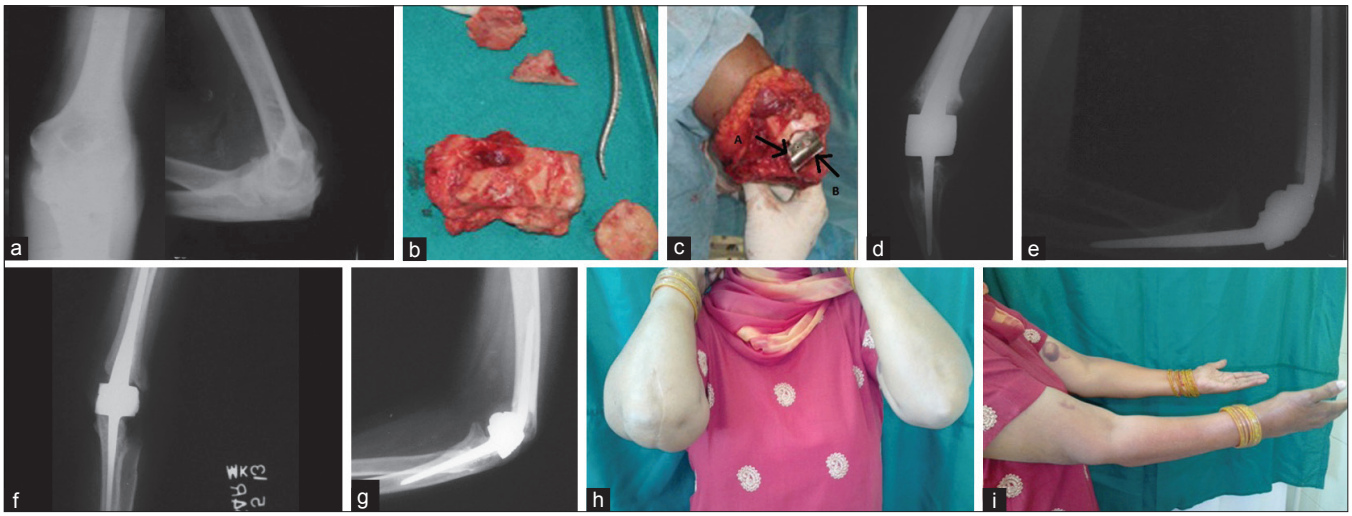

Figure 1: (a) Preoperative X-ray of right elbow joint (anteroposterior and lateral views) in a rheumatoid arthritis patient showing ankylosis of elbow in 90° flexion (b) photograph showing the excised part of fused elbow joint of the right side (c) photograph showing the humeral and ulnar hinged section of Baksi implant (black arrow) (d-e) Postoperative X-rays showing Baksi implant *in situ* (f-g) Final followup X-rays of right elbow (anteroposterior and lateral views) showing Baksi implant *in situ* without any signs of loosening (h-i) Clinical photographs showing flexion and extension of both elbow joints and surgical incision scar mark on posterior aspect of right elbow

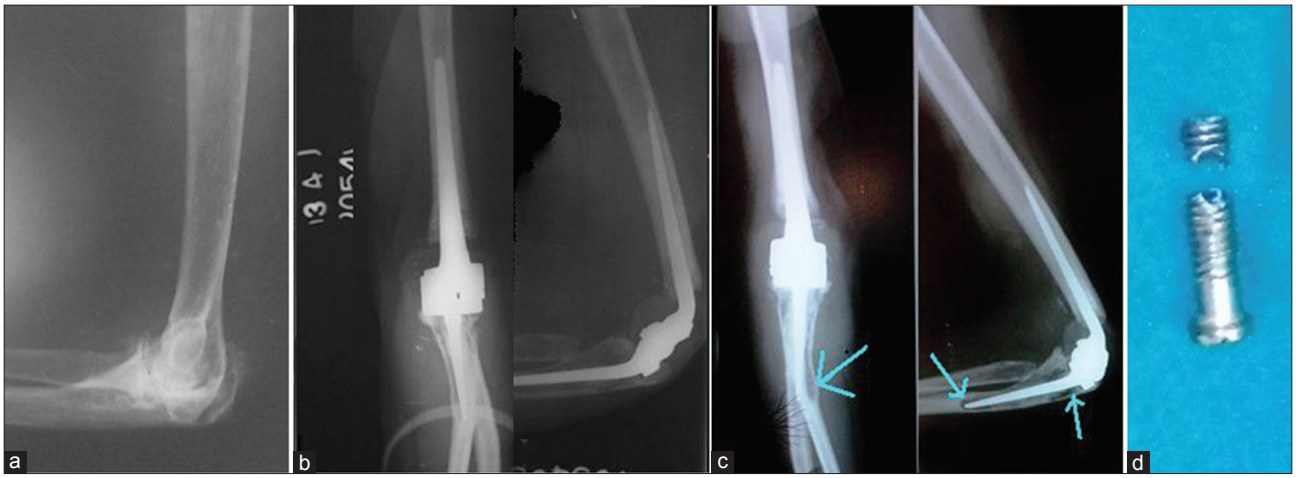

Figure 2: (a) Preoperative X-ray of left elbow joint (lateral view) in a post burn patient showing bony ankylosis of elbow in 90° joint (b) Postoperative X-ray of left elbow joint (anteroposterior and lateral views) showing Baksi implant *in situ* (c) X-ray left elbow (anteroposterior and lateral views) 117 months of followup showing radiolucency around stem (sky blue arrow) (d) photograph showing broken hinge screw at the level of threaded hole which lead to implant failure

The average operative time was 80 minutes (range 70 to 100 minutes). The followup was from 2 months to 117 months (mean 60 months). The evaluation of the patients was based on clinical as well as on radiological parameters. Pre-operatively eight patients had stable elbows as they had ankylosis in nonfunctional position between 80 to 90° due to rheumatoid arthritis or traumatic arthritis and also stable by virtue of bony fusion. Remaining four patients had unstable elbows because of fracture distal humerus and one of them having fracture ulna. Clinico-radiologically all the elbows were stable after surgery except one case which was having moderately unstable elbow [Table 1]. Postoperative X-ray was taken to see the placement of ulnar and humeral stem, bone cement interface [Figures 1d, e and 2b, c, taken after revision arthroplasty, Figures 3b, c and 4a].

In the present study, average supination was 70° (range 60-80°) and average pronation was 70° (range 60-80°). Average flexion was 135° (range 130-135°). However, in 5 cases, there was loss of 15 to 35° (average 25°) of extension (45%) out of 11 cases. The average Mayo elbow performance score was 95.4 points (range 70 to 100). A clinical photograph of a posttraumatic bony ankylosis, after total elbow replacement shows surgical incision scar mark on posterior aspect of right elbow and with flexion of both elbow [Figures 1h, and 3e], extension 135° of both elbow, operated on the right side [Figures 3d, and 1i] with full flexion [Figure 3e], supination of both forearms, 70°

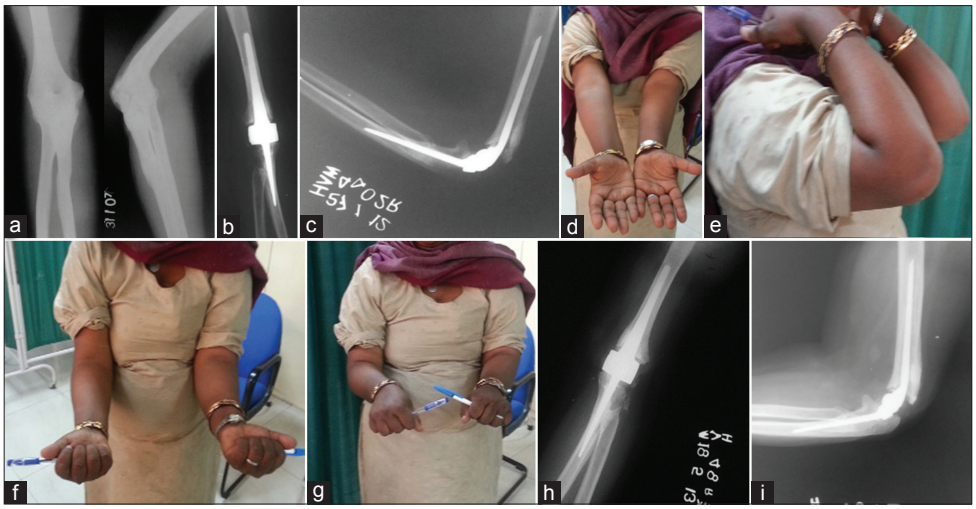

Figure 3: Preoperative X-ray of right elbow joint (anteroposterior and lateral views) in a posttraumatic arthritis showing (a) bony ankylosis of elbow joint (b-c) Postoperative X-ray of right elbow (anteroposterior and lateral views) showing Baksi implant *in situ* (d-g) Clinical photographs showing extension, flexion, supination and pronation (h-i) Final followup X-rays of right elbow showing Baksi implant *in situ*

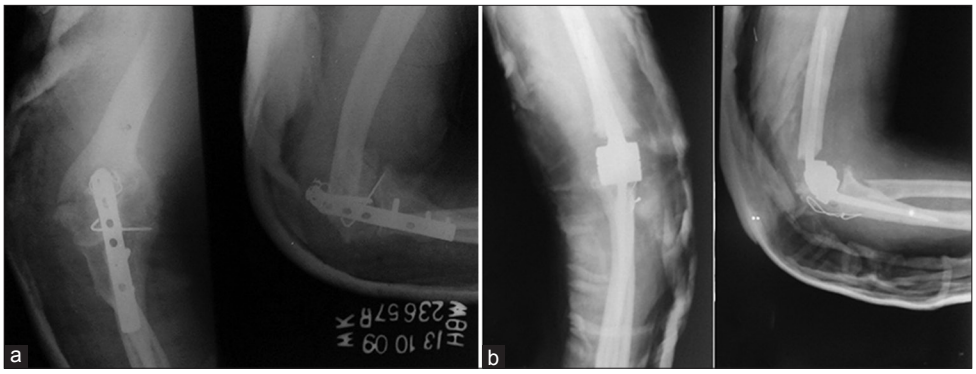

Figure 4: (a) X-ray of right elbow joint (anteroposterior and lateral views) showing malunited fracture of distal humerus with nonunion fracture of proximal ulna with implant failure. (b) Postoperative X-ray of right elbow anteroposter and lateral views showing Baksi implant *in situ*

supination on the right side [Figure 3f] and pronation of both forearms, 60° pronation on the right side [Figure 3g] on followup postoperatively. The final followup X-ray was taken to see the placement of ulnar and humeral stem, bone cement interface [Figures 1g, h and 3h, i]. In one case, radiolucency was seen [Figure 2c] on her final followup (after 117 months) and she was having mild pain on movement of the elbow. Revision arthroplasty was done and during surgery we found broken humeral hinge section at the level of threaded holes [Figure 2d], which might have lead to implant failure. Loose ulnar stem was easily taken out and a larger stem replanted. In other case, radiolucency was seen after 5 years but the patient did not turn up for followup. The arm length discrepancy was noted in four patients (36%) out of 11 cases [Table 1]. Clinico radiologically all the elbows were stable. In our series, we did not get complications like nerve palsies or triceps weakness. However, heterotrophic ossification and radiolucency was notice in two cases. Loosening of ulnar stem was seen in two cases (18%) out of 11 cases. One patient developed superficial infection postoperatively and after giving adequate antibiotics and proper dressing, infection was controlled.

Functional outcomes in the form of combing hair, holding a glass of water, buttoning the shirt, eating, writing and hand reaching the perineum, etc., were satisfactory in all the cases. All the patients were strictly advised not to lift any heavy objects postoperatively as it results in loosening of implant and decreases the life of the implant substantially.

Discussion

A sound understanding of the elbow anatomy and biomechanics is necessary for the treating surgeon. Isolated or combined injury to vital osseous and soft tissue structures of the elbow joint affects stability. Much work has been accomplished to identify and define the function of the key primary and secondary constraints of the elbow.[15-19]

Table 1: Clinical details of patients

Case no.	Age\ sex (years)	Diagnosis	Radiological radiolucency postoperatively	Pain	Infection	Extension/ flexion (°)	Supination/ /Pronation (°)	Arm length discrepancy (cm)	Stability	Function (units)	MEPS (units)	Followup (months)
1	28 F	PBBA	After 10 years	No	No	35-130	70/70	2.5	Moderately Unstable	20	70	117
2	50 F	PTBA	Yes	Yes	No	0-135	60/70	No	Stable	25	100	94
3	50 F	Nonunion fracture of distal humerus with deformed ulno-humoral with osteoporosis	After 5 years	No	No	15-135	70/80	2.0	Stable	25	100	72
4	60 F	RA	No	No	No	0-130	60/70	No	Stable	25	100	68
5	69 M	Comminuted intraarticular fracture of distal humerus	No	No	No	0-130	80/80	1.7	Stable	25	100	60
6	60 F	RA	No	No	Superficial	20-135	60/70	No	Stable	20	95	48
7	60 M	PTBA	No	No	No	0-130	80/70	No	Stable	25	100	46
8	56 M	Comminuted intraarticular fracture of distal humerus	No	No	No	30-130	80/80	No	Stable	15	90	30
9	45 F	RA	No	No	No	0-135	70/80	No	Stable	25	100	24
10	48 F	Malunited fracture of distal humerus with nonunion of fracture proximal ulna prominent hardware	No	No	No	25-140	70/60	1.5	Stable	20	95	23
11	38 F	PTBA	No	No	superficial	0-130	70/60	No	Stable	20	100	2

PBBA=Post burn bony ankylosis, PTBA=Post traumatic bony ankylosis, RA=Rheumatoid arthritis, ROM=Arc or flexion minus loss of extension, MEPS=Mayo elbow performance score, M=Male, F=Female

Elbow arthroplasty was associated with high complication rate previously and was warranted only for seriously disabled patients.[20,21] But nowadays due to improved implant design and surgeon experience, the complication rate has come down considerably. TEA is a well established treatment for painful elbow joint in patients with rheumatoid arthritis and comminuted fractures of distal humerus that have poor bone quality.[20,22,23] When the elbow joint damage is very advanced, as in stage 3 arthritis, producing pain and collateral ligament instability or if the elbow is so stiff that the activities of daily living cannot be performed, replacement arthroplasty must be considered. The problems of mechanical loosening of constrained (hinged) prostheses and dislocation of nonconstrained designs have been largely overcome by semi-constrained designs. Perfect balancing of soft tissues and accurate bone cuts are essential.[24] Cadaveric studies also showed that normal elbows behave as semi-constrained joints under physiological conditions.[25]

Severe elbow arthritis secondary to trauma or inflammatory disease is a difficult problem in the young or active individual. Treatment option includes resection arthroplasty, TEA, arthrodesis, and interposition arthroplasty.[14] There is concern that younger patients with posttraumatic arthritis will require additional surgery following semi-constrained total arthroplasty because of infection, fracture, or bushing wear.[26,27] Many of these complications can be attributed to strenuous use of the elbow, with forces applied across the joint being greater than the recommended 5-kg weight-lifting restriction. Interposition arthroplasty does not carry the same weight-lifting restriction as TEA does and may be more durable in the active patient. Interposition arthroplasty can preserve function in selected patients who have inflammatory arthritis of the elbow. For those with post traumatic arthritis, interposition arthroplasty serves as a salvage procedure to deter elbow fusion or TEA and to improve range of motion. It can also be successfully converted to TEA, if needed.[14]

Earlier, elbow arthroplasty was a relatively infrequent procedure and available literature was limited. However, now there is increasing evidence that support the overall efficacy of TEA with wider indications.[27,28] TEA has been used extensively in rheumatoid arthritis, posttraumatic arthritis, and comminuted fracture distal humerus with intraarticular extension in elderly patients.[29-31] It has also become the treatment of choice for most patients with tumor around elbow[32-34] and also may be used for palliation. TEA for intraarticular comminuted distal humerus fracture is a viable option for elderly low demand patients.[12] Distal humerus nonunion is one of the most difficult elbow conditions to treat successfully; limited bone stock, damage to the articular cartilage, joint contracture, and compromised bone viability are frequently associated with such nonunions and compromises the overall result when internal fixation is attempted.[35-37] Elbow arthroplasty is a very

useful, reliable joint replacement procedure in a selected group of patients with such nonunions and also has a high degree of patient satisfaction.[38-40] The success of elbow arthroplasty and advances in surgical technique and prosthetic design has broadened its indications in younger patients.[41] The results are satisfactory even in younger patients, provided that they were willing to accept permanent restriction of strenuous activities.[42]

Elbow arthroplasty have complication rate higher than total hip and knee arthroplasty, is likely inherent in the anatomic uniqueness of the elbow itself. With less bone stock for implantation as well as robust soft tissue envelope than the hip and knee, the surgeon must be careful with TEA.[43,44] The revision of failed TEA can be very challenging compared to revision of total hip and knee replacements owing to limited metaphyseal bone stock and soft tissue envelope.[45,46] In some cases, a loose total elbow replacement may be retained and removal of the prosthesis may result in an unstable and useless elbow. The situation may be retrieved to some extent by recessing the semilunar fossa in the residual humeral epicondyle. Revision of a TEA can give satisfactory results although in the absence of sufficient bone stock this may be impossible. A semi-constrained prosthesis is usually indicated in these cases.[34] Revision TEA for implant loosening, polyethylene wear, implant failure and periprosthetic fractures can result in satisfactory outcomes in a majority of patients.[47,48] For revision arthroplasty, whatever may be the cause for implant failure in TER, there will be osteolysis at bone and cement interface lead to the thinning of the cortex or perforation at some places in the cortex or less bone stock, is not an easy task for surgeons. Therefore, one should be aware of the high rate of complications of revision of failed TEA. To overcome these complications there is need of primary implant design to facilitate minimum failure rate as it is seen in total hip and knee replacement.

Modern TER implants fall into two design categories: Linked and unlinked. These terms are, generally, interchangeable with the descriptors semi-constrained and unconstrained, respectively.[13] Linked implants are coupled together with pins or snap-fit bushings that produce a semi-constrained hinged construction, allowing for a degree of laxity in the medial, lateral, and rotational planes that closely simulates the loose hinge of normal elbow kinematics. Unlinked or unconstrained implants are not mechanically linked but rely on matching shapes of the bearing surfaces, adequate bone stock, and most importantly, the integrity of the capsular and ligamentous structures. Both linked and unlinked TEA implants have similar functional outcome and patient satisfaction scores. However, because of the inherent differences in stability, they have different indications. The unlinked designs require competent soft tissue constraints and adequate bone stock to yield a stable arthroplasty; therefore, their use is often limited to or preferred when there is less bone or articular destruction. Moreover, as less bone is removed to implant the resurfacing unlinked prosthesis, it may be preferred in younger patients who may later need revision surgery. Semi-constrained-linked implants utilize a loose hinged mechanism allowing about 7-10° of varus-valgus laxity and 7-10° of axial rotation.[49] Inherent stability of the design allows for less dependence on surrounding capsule-ligamentous structures and the laxity of the hinge system is thought to decrease the incidence of aseptic loosening.[28] Implants with rigid hinged designs are associated with a high rate of failure and they are abandoned.[40]

To conclude TEA is usually not recommended in young patients, however it may have to be done in selected cases. In elderly patients, TEA is a suitable option. Limitations of the study are its small sample size, the procedure has been done in selected cases. Therefore, further research and development is required in prosthetic design for primary total elbow replacement and revision cases for better outcome.

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