Results of cementless total elbow arthroplasty using the Discovery elbow system at a mean follow-up of 61.8 months

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Background: The available literature on the use of a cementless total elbow arthroplasty (TEA) design and its results are limited. This clinical study reports the outcome of the cementless Discovery elbow system.

Methods: Patients were operated on by a single surgeon between 2007 and 2014. Nineteen patients (20 elbows) were available for review, 2 women (1 bilateral TEA) and 17 men. The age of the patients ranged from 27 to 75 years (mean, 48 years). The mean follow-up was 61.8 months (range, 12-156 months). Patients were assessed for range of motion, pain, and satisfaction level. Outcome scores included the Mayo Elbow Performance Score, the Liverpool Elbow Score, and the 12-Item Short Form Health Survey (version 1). Radiographs were reviewed to evaluate for loosening.

Results: The mean Mayo Elbow Performance Score was 77.25, and the mean Liverpool Elbow Score was 6.76. The mean flexion range was 123°, and the mean extension lag was 35°. The mean pronation was 59°, and the mean supination was 58°. On radiologic evaluation, there were no signs of loosening; however, in 2 cases, nonprogressive radiolucent lines were observed. No signs of infection were detected at final follow-up, and no elbows were revised. More than 90% of patients were satisfied with the overall outcome.

Conclusion: The cementless TEA seems to be a reliable option for treatment of varying elbow diseases. Long-term results are needed to assess the survivorship of this design.

Level of evidence: Level IV; Case Series; Treatment Study

Keywords: Total elbow arthroplasty; Discovery elbow; clinical outcome; cementless; loosening; linked
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factors that may
have led to improvements in surgical outcomes for patients. Aseptic loosening of components, mainly the ulnar stem, is
the leading cause of implant failure in a TEA. Whereas loosen-
ing can be caused by the primary failure of the bone-
cement interface, secondary failure is associated with osteolysis
initiated by particle debris from the polyethylene or cement
or infection. The biomechanical properties of the TEA
design have a profound impact; aseptic loosening occurred in
25% of the abandoned constrained designs, in 6%-17% of
the semiconstrained designs, and in <2% of the nonconstrained
designs. Polymethyl methacrylate has been used for >60 years. Cemented implants were designed to accommodate high
stress loads as the cemented implants transfer the load over
a larger surface area compared with the cementless implants; however, the successful use of cement can depend on surgi-
cal technique of cementation. Concerns about aseptic loosening and cement inducing third-body wear, along with the promise of biologic fixation and bone preservation, have led to the popularization of cementless implants. In 2003, the most common total hip replacement (THR) was the all-
cemented implant used in 60.4%, whereas an all-cementless THR was used in only 16.8%, with hybrid THR implants used
in 12.3%. During 13 years, there has been a significant in-
crease in the cementless option; in 2016, all-cemented implants
represented only 31.0%, whereas an all-cementless THR has
surged to 39.4% and hybrid THR implants have doubled to
25.7%. Reports suggest that the increased use of a cementless
design in joint replacements is underpinned by an increased
interest in the patient’s function and the implant’s long-
vity, with no significant differences seen in long-term outcomes. Despite this, the use of a cementless TEA
design is less popular than in other joints. Factors that may
have limited its use were early poor results with a cementless
TEA, frequently implanted as a hybrid, often together with
small numbers of patients reported, short follow-up, and the
lack of Food and Drug Administration approval for cementless
use until recently. Furthermore, most of the cementless
implants were unconstrained prostheses, which may have been
a key issue in the failures observed.
The limitations of previous studies included implants that
are no longer in use, small numbers, and results based on
limited assessments, such as radiologic signs of looseness and
pain or cohorts of patients with rheumatoid arthritis. This study
aimed to look at patients’ postoperative functional joint-
specific scores while examining their overall satisfaction and
radiographic evaluation, thus giving an overall outcome
assessment.

Methods

Patients

A retrospective review was conducted of a case series including all
primary cementless TEAs performed in a single center by the same
surgeon (S.P.F.; July 2007–August 2014). Nineteen patients (20
elbows) were available for review at an arthroplasty review clinic;
1 patient had bilateral TEA with the cementless design, and 2 further
patients were lost to follow-up. Three other patients had the con-
tralateral elbow replaced with a cemented Discovery elbow (Biomet,
Warsaw, IN, USA) total elbow replacement. The inclusion criteria
were all patients who had implantation of the Discovery elbow using
the cementless design only.

All patients were seen and assessed at clinical review with a ra-
diograph of the elbow performed in an anteroposterior view at
maximum extension and a lateral view in 90° of flexion. All adverse
radiologic findings were recorded, with evaluation of loosening un-
dertaken using the Discover elbow radiologic assessment criteria. Scores and clinical assessments were completed by the experi-
enced research team. The joint-specific scores used were the Mayo Elbow Performance Score (MEPS) and the Liverpool Elbow Score
(LES). The validated LES assesses the elbow joint objectively and
subjectively. It consists of a 9-item patient-answered questionnaire
(use of other arm, combing hair, washing, feeding, dressing, house-
hold activities, lifting, pain, sport and leisure) and a 6-item clinical
assessment (flexion, extension, pronation, supination, strength, and
ulnar nerve). ROM was obtained by an experienced team member
while the patient was standing; active range of flexion, extension,
pronation, and supination was recorded. The LES has been dem-
onstrated to be reliable, internally consistent, responsive, and sensitive
to changes in the patient’s elbow condition. All responses are entered
on a numerical scale, where 0 is the worst and 10 is the best.

Patients’ outcomes were also assessed using a satisfaction level and
pain score. Patient satisfaction was measured using a 4-point Likert
scale, as follows: 0, not satisfied; 1, somewhat satisfied; 2, satis-
fied; and 3, very satisfied. Pain was rated by the patients as follows:
0, none; 1, mild; 2, moderate; and 3, severe. The 12-Item Short Form
Health Survey, version 1 (SF-12v1), a short version of the 36-
Item Short Form Health Survey from QualityMetric, is a generic
health care survey, recording patients’ functional health and well-
being from their point of view. The SF-12v1 survey provides a
psychometrically based physical component summary and a mental
component summary; a score of 50 is the average score.

Data were entered into Excel (Microsoft, Redmond, WA, USA) and
analyzed using SPSS Statistics for Windows (version 24.0; IBM,
Armonk, NY, USA).

Cementless implant design and surgical procedure

The Discovery elbow system has been designed to avoid compli-
cations associated with other TEAs, and it has been modified to allow
press-fit implantation; instruments have been changed, and differ-
ent reamers are used. This system facilitates more accurate positioning
of the elbow flexion-extension axis, ensuring stability without using
a true hinge. Hence, its “floppy hinge” allows 6° to 8° of varus-
valgus motion and a rotational motion; the increased area of contact
between the cobalt-chrome and ultrahigh-molecular-weight poly-
ethylene avoids edge loading and reduces stresses in the ultrahigh-
molecular-weight polyethylene, and the design allows posterior access
during bushing revision. The cementless stem has a porous coating
and hydroxyapatite coat to enhance the biologic integration. The
design is a reliable option for patients with disabling elbow disease as
it restores the functional arc of motion that is needed for activi-
ities of daily living.

Patients were operated on in a lateral position; a posterior midline
incision was used, and the ulnar nerve was identified and pro-
tected. The Newcastle approach was used in all patients. After the
development of medial and lateral skin flaps, which are held by stay sutures, the triceps aponeurosis is identified and raised as a distally based flap. The radial-sided incision along the aponeurosis is extended distally over the anconeus and along the radial border of the ulna. The ulnar reflection of the aponeurosis is made on the radial side of the median raphe until approximately 1 cm proximal to the insertion on the olecranon. At this point, the median raphe is divided and the fascia along the ulnar border of the ulna incised distally. The plane between the medial and long heads of the triceps is split, and the triceps is released from the insertion onto the olecranon. On the radial side, the anconeus is released from its insertion. The medial collateral ligament is identified and released from the humerus. The lateral collateral ligament complex is also released from the humerus. The anterior capsule is released from the coronoid, and the insertion of the brachialis may need to be released, particularly where there is a major restriction of extension. The elbow is dislocated. The humerus and ulna are prepared as described in the operative technique but with use of instruments specifically designed for cementless implantation. Trial implantation and reduction are undertaken. The hydroxyapatite-coated components are implanted, and the humeral and ulna components are linked using the standard hexalobular condyle set. Fine wire is used to reconstruct the triceps aponeurosis, and a polysling is used for the first 2 weeks of recovery.

The Guide for Orthopaedic Surgeons and Therapists postoperative rehabilitation protocol was applied.20 In the first 2 weeks, active assisted flexion exercises progress as pain allows; passive assisted extension is commenced according to wound healing, triceps status, and surgical details. Pronation-supination, shoulder, wrist, and hand exercises in 90° are encouraged. Varus-valgus strain must be avoided.

At 2 weeks, while these exercises are being maintained, pronation-supination is applied through the active flexion-extension range. At 6 weeks, the muscle control of all movements is checked and antigravity triceps action established; the elbow is expected to achieve passive movement equal to preoperative movement. At 12 weeks, triceps control through the full ROM is checked; a full preoperative active ROM is expected to be regained.

Results

Of the 19 patients available for review, there were 2 women and 17 men. The mean age was 48 years (range, 27.5-75 years). The mean follow-up was 61.8 months (range, 12-156 months). Patients presented with differing underlying diseases as detailed in Table 1.

Radiographic outcome

All radiographs were reviewed by an independent reviewer (Fig. 1). None of the patients had loosening during their follow-up time. However, 2 cases (10%) had nonprogressive radiolucent lines identified on the follow-up radiographs:

Patient 1 (hemophilic arthropathy, 46 years of age at surgery): Fine radiolucent lines <1.5 mm appeared at 6 months postoperatively, in ulnar zones 1, 3, and 4 and humeral zones 5, 6, and 8, and remained stationary throughout the follow-up period. This same patient had a contralateral cemented TEA 7 months earlier, which also showed nonprogressive radiolucent lines <1 mm around the proximal part of the ulnar component.

Patient 2 (rheumatoid arthritis, 75 years of age at surgery): Fine radiolucent lines <1 mm appeared 3 years postoperatively, in humeral zones 1-4, and remained stationary throughout the follow-up period. This patient also had a contralateral cemented TEA 3 years earlier with no radiologic adverse signs or loosening.

Despite radiolucent lines being reported, both patients were very satisfied and no pain was reported.

Radiologic examination revealed no bushing wear or signs of instability. As no cases required revision, no macroscopic observation of the bushings or laboratory microscopic evidence of wear in revision tissue samples was available. There were no infections.

Clinical outcome

The ROM as mean and range in degrees was as follows: flexion, 123° (90°-150°); extension lag, 35° (10°-90°); total arc of flexion-extension, 88° (45°-140°); pronation, 59° (0°-90°); supination, 58° (0°-90°); and total arc of pronation-supination, 118° (0°-180°). The mean MEPS was 77.25 (range, 5-100). The mean LES score was 6.76 (range, 1.83-9.39). Evaluation of pain documented 13 patients with no elbow pain (65%), 4 patients with mild pain (20%), 1 patient with moderate pain (5%), and 2 patients with severe pain (10%). The patient with moderate pain at 3 years postoperatively had primary elbow osteoarthritis and cervical spine problems treated conservatively for radicular pain.

One patient with severe pain had juvenile rheumatoid arthritis; age at surgery was 40 years, and the follow-up period was 8 years postoperatively. The contralateral side, also with a cementless TEA, had no pain at all. The second patient with severe pain had post-traumatic osteoarthritis; the age at surgery was 46, and the follow-up period was 13 years postoperatively.

None of the 3 patients with moderate or severe pain had any radiologic or clinical complications. Fourteen patients reported that they were very satisfied with the outcome (70%),
4 patients stated that they were satisfied (20%), and 1 patient was somewhat satisfied (5%). Only 1 patient was not satisfied (5%); the reason given was the poor upper limb function as the patient had a shoulder replacement also in the same arm.

The mean SF-12v1 physical component summary score was 37.4 (range, 17.8-57.66), and the mean SF-12v1 mental component summary score was 54.77 (range, 19.1-68.6).

There were no infections. One patient (5%) had long-term sensory ulnar nerve symptoms.

**Discussion**

This study details the results of a commonly used TEA in which the device and instruments have been modified specifically to allow cementless implantation into both the humerus and ulna.

Twenty TEAs were implanted into 19 patients. This small series has a number of demographic differences from typical elbow data entered into the UK National Joint Registry. In this series, the majority of the patients are male, whereas the National Joint Registry report showed that TEAs are more frequently performed in women (73%) than in men (27%). Furthermore, in this study, the mean age was 47.97 years, whereas the National Joint Registry reported a mean age of 66.9 years for women and 65.9 years for men at the primary procedure. Age and gender have a strong correlation with the type of joint replacement and fixation used within arthroplasty surgery. The cementless design of total joint replacement is purported to preserve bone stock, to produce no polyethylene wear debris, to require shorter operative times, and to offer easier revision surgery. Thus, a cementless TEA might provide a better long-term option for a younger patient if these goals can be achieved. Younger patients with high bone quality and high metabolic activity represent the typical candidates for cementless implantation. As always, it is important to achieve biologic fixation properly, and the advances in the stem’s coating and the introduction of hydroxyapatite have decreased the micromotion and promoted integration; indeed, cementless total knee implantation was found to be successful in older patients (those >75 years old).

The majority of patients in this study were very satisfied and had a good rating within the MEPS score. This indicates that the cementless TEA provided a good result whereby patients are able to perform their own activities of daily living most satisfactorily.

If hybrid design reviews are excluded, there are only a few studies of true cementless designs in the literature against which to compare our results, and none of these used the Discovery elbow system. Reinhard et al reported results using the Kudo type-4 unconstrained prosthesis in 45 patients (57 elbows) and found that fatigue breakage of the humeral stem (5 patients) and ulna loosening (7 patients) were the main complications, attributed to the high ulna loosening rate of the
cementless prosthesis. Our results of this study run contrary to these observations. van der Heide et al\textsuperscript{12} also looked at a long-term follow-up and survivorship of the Kudo type-5 total elbow replacement in both cemented and cementless placement at a mean follow-up of 6 years. Seven of 49 patients in the cementless group needed revisions. In each case, the ulnar component was loose; thus, they recommended that as the Kudo is an unlinked, minimally constrained prosthesis, the ulnar component should not be inserted without cement.

Last, Fevang et al\textsuperscript{13} reported that the Norwegian Arthroplasty Register carried out 562 total elbow replacements of varying types between 1994 and 2006. They noted that in the 27 patients who received a cementless ulna component, the risk of revision was 3 times higher than within the cemented group.

The only study that found encouraging results using a cementless design was reported by Cross et al\textsuperscript{14} with a semiconstrained TEA. The results of 14 custom, noncemented, semiconstrained TEAs (Osteonics, Allendale, NJ, USA) were examined at a mean follow-up of 18 years; 4 patients had rheumatoid arthritis, and 6 patients had juvenile rheumatoid arthritis. The ROM and other elbow scores had at least doubled postoperatively. Despite the revision rate (29%), which was only for isolated bushing changes, there was no evidence of loosening or loss of fixation at the end of follow-up.

Many studies have reported the results of standard cemented TEA. Such comparison would be difficult, given the different prosthesis designs, inclusion of revisions cases, and different scoring systems. Thus, our comparison is limited to the latest results from linked prostheses only.

Two recent studies examined the results of the cemented Discovery TEA, Alizadehkhaiyat et al\textsuperscript{1} and Hastings et al.\textsuperscript{18} Two studies examined the results of the cemented Coonrad-Morrey TEA, Mansat et al\textsuperscript{26} and Sanchez-Sotelo et al.\textsuperscript{37} The number of patients recruited varied; this study had a small group of 20 elbows compared with 100, 46, 78, and 461 elbows in the studies of Alizadehkhaiyat et al,\textsuperscript{1} Hastings et al,\textsuperscript{18} Mansat et al,\textsuperscript{26} and Sanchez-Sotelo et al,\textsuperscript{37} respectively.

Our mean follow-up period (5.15 years) was comparable to that of the first three studies: 4 years, 4.1 years, and 5 years, respectively. The study of Sanchez-Sotelo et al\textsuperscript{37} had a longer median follow-up period (10 years). This study had the youngest mean age at surgery of 48 years compared with the 60s in all other studies.

All patients in our series underwent primary arthroplasties, as in the studies of Hastings et al,\textsuperscript{18} Mansat et al,\textsuperscript{26} and Sanchez-Sotelo et al\textsuperscript{37} but unlike in the study of Alizadehkhaiyat et al,\textsuperscript{1} who included 25 revisions with 75 primary arthroplasties. Preoperative diagnosis of inflammatory arthritis represented 45% in our series, similar to the 54%, 50%, and 58% in the studies of Alizadehkhaiyat et al,\textsuperscript{1} Hastings et al,\textsuperscript{18} and Mansat et al,\textsuperscript{26} respectively, but unlike in the study of Sanchez-Sotelo et al,\textsuperscript{37} with the highest percentage of inflammatory arthritis at 84%.

The postoperative clinical outcomes have been reported in different ways. Using the LES, we had a mean of 6.67, which is slightly higher than 6.36 reported by Alizadehkhaiyat et al.\textsuperscript{1} Our MEPS was 77.25, which is inferior to 86 and 90 reported by Mansat et al\textsuperscript{26} and Sanchez-Sotelo et al,\textsuperscript{37} respectively.

ROM measurements have been expressed in mean total arc of motion. The mean total arc of flexion-extension in this study was 88° compared with 93°, 121°, 103°, and 115° in the studies of Alizadehkhaiyat et al,\textsuperscript{1} Hastings et al,\textsuperscript{18} Mansat et al,\textsuperscript{26} and Sanchez-Sotelo et al,\textsuperscript{37} respectively. The mean total arc of pronation-supination in this study was 118° compared with 111°, 163°, and 139° in the studies of Alizadehkhaiyat et al,\textsuperscript{1} Hastings et al,\textsuperscript{18} and Mansat et al,\textsuperscript{26} respectively.

Pain was reported as no or mild pain in 85% of our patients, comparable to 3 studies, Alizadehkhaiyat et al,\textsuperscript{1} Mansat et al,\textsuperscript{26} and Sanchez-Sotelo et al,\textsuperscript{37} who reported 75%, 91%, and 78%, respectively. Patient satisfaction level on the Likert scale was 90% (very satisfied, satisfied) compared with 86% in the study of Alizadehkhaiyat et al\textsuperscript{1} and 83% in the study of Mansat et al,\textsuperscript{26} Hastings et al\textsuperscript{18} reported pain and satisfaction within the American Shoulder and Elbow Surgeons score, making comparisons difficult.

On radiologic evaluation, we had no loosening with 10% nonprogressive radiolucent lines. Alizadehkhaiyat et al\textsuperscript{1} had 17% progressive aseptic loosening requiring revision. Hastings et al\textsuperscript{18} had 2.2% loosening, but not revised, and 15.2% nonprogressive radiolucent lines. Mansat et al\textsuperscript{26} reported 22% radiolucencies around the humeral component (5% loosening) and 18% around the ulnar component (6% loosening). Sanchez-Sotelo et al\textsuperscript{37} had 2.6% with radiographic evidence of loosening, but they were not yet revised.

This study reports no infections or revisions in the series but reports 1 complication as 1 elbow (5%) presented with long-term ulnar sensory symptoms. Alizadehkhaiyat et al\textsuperscript{1} had complications of TEAs in 16%, of which 9% required formal revisions; 1% screw failure needed exchange surgery. Hastings et al\textsuperscript{18} had a 43.5% complication rate, around 10% related to screw or bearing failure; other complications were observed primarily of a general surgical nature. Mansat et al\textsuperscript{26} documented a 34.6% complications rate; 9% required formal revision surgery, and bushing changes were done in another 18% of elbows. Sanchez-Sotelo et al\textsuperscript{37} had a 21% complication rate; 8.8% of the elbows had undergone component revision because of mechanical failure (humeral, ulnar, or both).

Our series presents comparable results to those evaluating a linked cemented design. The small number of patients is a limiting factor that may hinder wider appreciation of the results.

**Limitations**

Preoperative scores would allow enhanced comparison with postoperative data and would detail patients’ global improvement. ROM together with the MEPS, LES, and SF-12v1 was
used as an efficient postoperative clinical outcome evaluation. The medium follow-up of this small group of patients with different demographics and diseases makes generalization of typical outcomes premature. Larger numbers are needed with a longer follow-up to fully assess the cementless design survivorship and for the assessment of any late complications.

Conclusion

The cementless TEA seems to offer a reliable option for treatment of varying elbow diseases; nevertheless, long-term results and greater numbers of patients are needed to assess the survivorship of this design. Overall, the majority of patients were satisfied with the outcome of surgery, and this was reflected in the joint-specific scores and satisfaction levels.

Disclaimer

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