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Original Article

Use of Modular Tantalum Augments for Acetabular Defects in Total Hip Arthroplasty

Ahmed Ashraf Abd el-salam Mohamed[1*], Aly Tawfique Elalfy [1], Mohamed Mahmoud El-Hefnawy[1], Mohamed Kotb[1]

[1] Orthopedic Surgery Department, Faculty of Medicine, Zagazig university

[*]Corresponding Author:

Ahmed Ashraf Abd El-salam Mohamed

E-mail: ahmed.ashraf11095@gmail.com

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ABSTRACT

Background: It can be difficult to reconstruct acetabular flaws among revision hip arthroplasty cases. Tantalum acetabular augments are a novel strategy approach for treating uncontained acetabular deformities. This material has a higher coefficient of friction against bone and a lower bulk stiffness than conventional porous materials like titanium. This study aimed to evaluate clinical, and radiographical outcomes as well as complications of modular tantalum augment in hip arthroplasty. **Methods:** In a prospective cohort study, that was conducted on 12 cases who underwent fixation of tantalum augment in hip arthroplasty at Orthopedic Surgery Department, Faculty of Medicine, Zagazig University. Tantalum acetabular augments were used as a new approach for managing uncontained acetabular defects. Clinical and radiological outcomes were assessed of modular tantalum augment for 2 years post-operation. **Results:** There was a highly significant improvement in quality of life (WOMAC Osteoarthritis Index for function, pain, and stiffness) as well as SF-12 mental component after treatment ($p<0.01$). There was highly significant improvement of the UCLA Satisfaction scores after treatment ($p<0.01$) as well. **Conclusion:** Satisfactory clinical as well as radiographic outcomes were obtained by modular Tantalum Augments for the reconstruction of acetabular defects in total hip arthroplasty. This approach increases the rate of stable fixation.

Keywords: Modular Tantalum Augments; Acetabular Defects; Total Hip Arthroplasty.

INTRODUCTION

The number of people who have total hip replacements (THRs) done each year is steadily rising. Most patients report long-term satisfaction with their prosthetic hips, however about 17% of these devices fail and require revision. Significant acetabular bone defects are often present when hip prosthesis revision is performed, making this clinical option one of the most challenging approaches in hip surgery. There is a wide range of surgical techniques and hardware for managing these defects [1].

When performing a revision hip arthroplasty, it can be difficult to reconstruct acetabular defects. Porous-coated hemispheric cups, with or without additional allografts, can be used to successfully reconstruct small, contained lesions. [2]. Cementless cups do not engage with enough host bone to provide primary stability with bigger, uncontained defects, no matter how many screws are used [3].

Extra-large hemispherical cups, high hip center implantation, cement impaction grafting, bilobed oblong cups, reconstructive cages as well and structural allografts are some of the surgical options [4]. Tantalum acetabular augments are a novel method for managing uncontained acetabular deformities. Tantalum porous material was invented around 10 years ago [5]. This material has a higher coefficient of friction against bone and a lower bulk stiffness than conventional porous materials like titanium [6].

Bone and other tissues attach and expand quickly in canine and small mammal models, according to histological analysis. The capacity to enable biological fixation of the augment to the host bone is an attractive feature of tantalum acetabular augments for use in the reconstruction of acetabular defects, in addition to metal augmentation's intrinsic resistance to fractures and failure helps prevent the deterioration of structural allograft that can occur with revascularization and remodeling over time. To insert a porous hemispherical shell made of tantalum, the defect must be filled with an augment. These augments come in a variety of sizes and shapes, making them suitable for use in a wide variety of complex acetabular revision surgeries [7].

Total hip revision (THR) with an acetabular component is dependent on the reconstruction of the acetabulum and repositioning of the hip joint's center of rotation. [8]. There are three main principles of acetabular revision arthroplasty; 1st one is doing a stable fixation of the revision cup in the acetabular defect after bony reconstruction which is the 2nd principle, and the 3rd principle is restoring the rotation center to preserve long-term stability [6].

It is hypothesized that tantalum has high coefficient of friction which results in improved implant stability compared with traditional uncemented titanium implants. In addition to favorable biomechanical properties, porous tantalum augments greatly increase the intraoperative versatility of acetabular reconstruction as they allow for on-table customization of cup-augment configuration in accordance with the type of acetabular defect to be addressed.

This study aimed to evaluate clinical and radiographical outcome of modular tantalum augment and to report complications related to the revision procedure in a prospective cohort of patients who underwent complex acetabular reconstruction with trabecular metal augments and revision shells.

METHODS

This is a prospective cohort study that was conducted on 12 cases who underwent fixation of tantalum augment in hip arthroplasty at Orthopedic Surgery Department, Faculty of Medicine, Zagazig University, during the period from June 2021 to June 2023. The follow up period was 2 years after surgery.

Inclusion Criteria: Cases with post traumatic acetabular defects, revision hip arthroplasty, or congenital acetabular defects within age group 20 -60.

Exclusion criteria: Cases who refused or being unfit for the operation**.**

The ethical committee at Zagazig University approved the study (IRB #10335/17-1-2023). All participants signed a written consent form. The study was performed according to The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Methods:

Complete history taking was done including personal, present history with special emphasize on any current medical treatment or previous surgical operations done. Full Clinical examination involving general as well as local examinations. Investigations included: Routine preoperative investigations were done including complete blood count (CBC), Random blood sugar, Liver and kidney functions and coagulation profile. Imaging included ultrasound examination and computed tomography.

Surgical Technique:

All cases undergone general anesthesia, they were at lateral position, under complete aseptic conditions an incision was made 10 cm below tip of greater trochanter. Blunt dissection of subcutaneous tissue till reached inter nervous plane between sup gluteal nerve and femoral nerve between vastus laterals and gluteus medius muscles. On reaching capsule of hip joint, we opened it in L shaped then reaching femoral head and neck.

We performed dislocation of femoral head to allow full exposure of head and get a look on acetabular defect then found a superolateral defect after reaming of acetabulum and that’s why we thought for tantalum augment. We set the tantalum augment at the place of defect then make trials for the size of the cup to allow good cup augment contact. We removed diseased and damaged bone and cartilage leaving healthy bone intact. We inserted the metal stem on top of thighbone then top by the replacement cup. We tested the joint stability to make sure that is dislocatable. We took an Xray photo by c Arm to justify the position of cup augment and stem.

Follow up*:* clinical and radiological outcome of modular tantalum augment for 2 years.

Statistical Analysis:

IBM Corp. Released 2015 was used for data collection, tabulation, and statistical analysis. Statistics by IBM SPSS Model 23 for Windows. IBM Corp., Armonk, New York. Mean standard deviation and median (range) were used to describe quantitative data, whereas quantity and adjectives were used to describe qualitative data (percentage). Two sets of normally distributed variables were compared using the t test. Two groups of non-normally distributed variables were compared using the Mann-Whitney U test. Chi-square and Fisher exact tests, respectively, were used to compare percentages of categorical variables. Predictive analysis using logistic regression to describe and explain the relationship between a single category dependent variable and several independent continuous or categorical independent variables; Hosmer and Lemeshow test used to determine model fitness.

RESULTS

This study is a prospective cohort study that was carried out at Orthopedic Surgery Department, Faculty of Medicine, Zagazig University. We found that the study population mean age was 50 ±12 , 33.3% of them were found males (Table 1).

As regards Paprosky classification 25% of patients 2A, 58.33% with 3A , 8.33% with 3B and 8.33% with 2C (Table 2).

Regarding preoperative characteristics, the mean WOMAC function 34.85 ± 16.5, the mean of WOMAC stiffness was 42.2 ± 14.63, the mean WOMAC pain was 48.6 ± 18.7, the mean WOMAC global was 34.31 ± 10.04, the mean Oxford score was 33.33 ± 13.39, the mean SF-12 physical component was 26.95 ± 8.61 and the mean SF-12 mental component was 45.99 ± 15.04 (Table 3).

Regarding preoperative UCLA satisfaction scores, it was found that the mean function score was 73.25 ± 3.78, the mean pain Score was 79.0 ± 11.04, the mean Recreational Score was 76.31 ± 7.03, the mean overall Score was 93.29 ± 5.32 and the mean Total Score was 80.13 ± 9.08 (Table 4).

There was highly significant improvement in quality-of-life data (Oxford Hip Score, WOMAC, and SF-12 mental component) after treatment (p<0.01) (Table 5).

There was highly significant improvement of the UCLA Satisfaction scores after treatment (p<0.01) (Table 6).

Table 1: Demographic data

Variables	**Study population N=12 (100%)**
Age	
Mean ± SD	50 ±12
Sex	
Males N(%)	4(33.3%)
Females N(%)	8(66.67%)
BMI	
Mean ± SD	21 ± 3.1

BMI: Body mass index SD: Standard deviation

Table 2: Co-morbidity and Paprosky classification

Variables	**Study population N=12 (100%)**
Paprosky classification	
2A	**3(25%)**
3A	**7(58.33%)**
3B	**1(8.33%)**
2C	**1(8.33%)**

Table 3: Preoperative disease characteristics

Variables	Mean ± SD
WOMAC function	**34.85 ± 16.5**
WOMAC stiffness	**42.2 ± 14.63**
WOMAC pain	**48.6 ± 18.7**
WOMAC global	**34.31 ± 10.04**
Oxford score	**33.33 ± 13.39**
SF-12 physical component	**26.95 ± 8.61**
SF-12 mental component	**5.99 ± 15.04**

SF-12: Short-Form 12 Health Survey

Table 4: preoperative UCLA Satisfaction scores

UCLA Satisfaction scores	Mean ± SD
Function	**73.25 ± 3.78**
Pain	**79.0 ± 11.04**
Recreational	**76.31 ± 7.03**
overall score	**93.29 ± 5.32**
Total score	**80.13 ± 9.08**

Table 5: Quality of life of the study population before and after treatment

	Baseline	Follow up	P value
WOMAC function	34.85 ± 16.5	72.54 ±22.74	**<0.01**
WOMAC stiffness	42.2 ± 14.63	86.84 ±11.15	**<0.01**
WOMAC pain	48.6 ± 18.7	94.31 ±13.41	**<0.01**
WOMAC global	34.31 ± 10.04	83.15 ±8.15	**<0.01**
Oxford score	33.33 ± 13.39	81.14 ±12.85	**<0.01**
SF-12 physical component	26.95 ± 8.61	46.29 ±10.25	**<0.01**
SF-12 mental component	45.99 ± 15.04	53.70 ±17.43	**<0.01**

Table 6: UCLA Satisfaction scores before and after treatment

UCLA Satisfaction scores	Baseline	Follow up	P value
Function	73.25 ± 3.78	88.71 ±16.73	**<0.01**
Pain	79.0 ± 11.04	96.29 ±17.43	**<0.01**
Recreational	76.31 ± 7.03	83.15 ±17.52	**<0.01**
Overall score	93.29 ± 5.32	103.13 ±8.86	**<0.01**
Total score	80.13 ± 9.08	92.50 ±10.45	**<0.01**

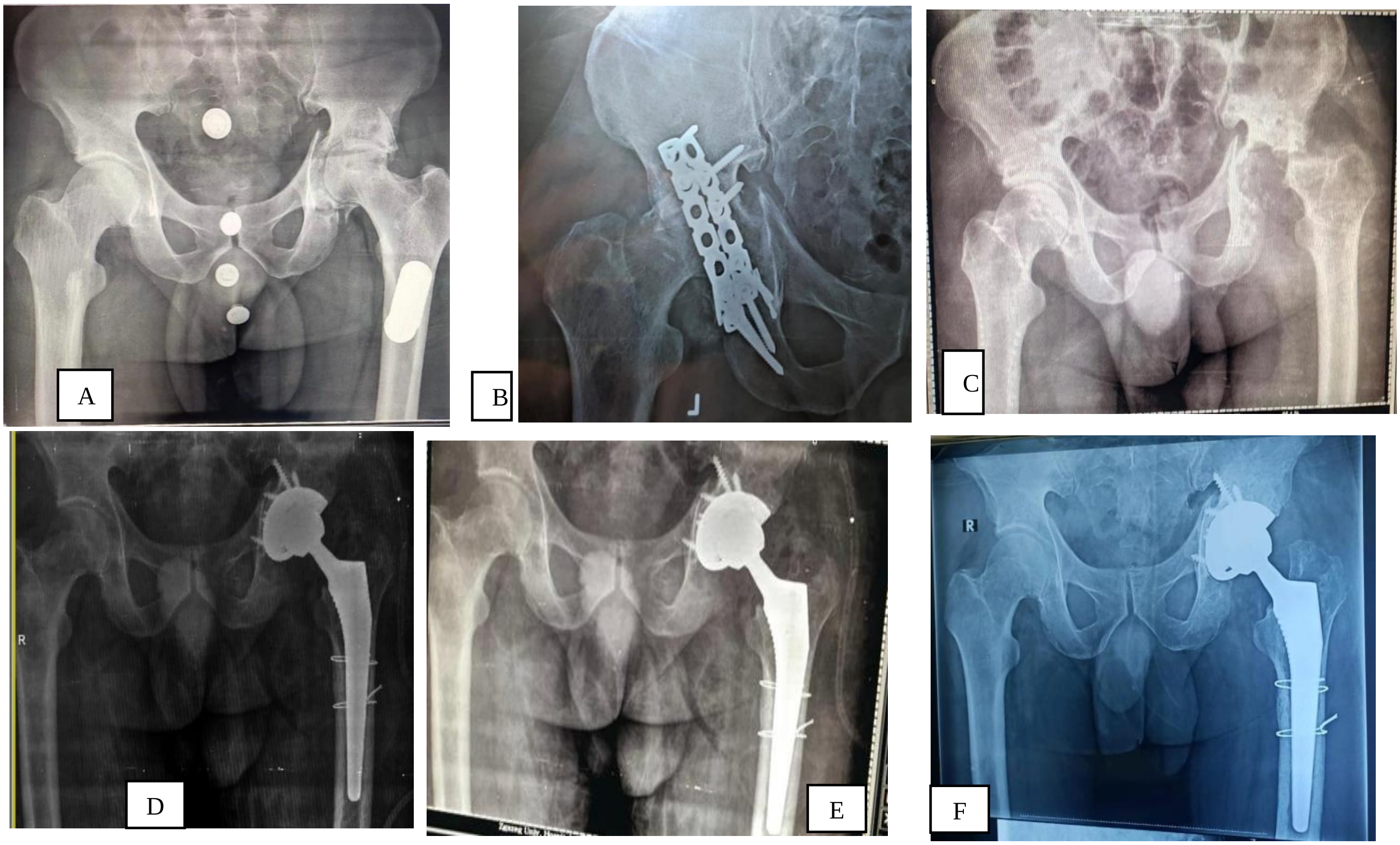

Figure 1: 46 years old patient who had road traffic accident presented with acetabular fracture and underwent total hip arthroplasty with tantalum augment, (A): acetabular fracture 2 years ago, (B): Acetabular fracture fixed with plate and screws, (C): Patient presented after 2 months with infected acetabular plate, (D): Patient underwent total hip arthroplasty with tantalum augment day 1 post-operative x ray, (E): First follow up after 1 month, (F): follow up after 2 years.

Figure 2: (A): Female pt 39 years old presented with LT acetabular fracture 2.5 years ago fixed with plate acetabulum (B): Infected acetabular plate extraction after 4 months (C): Patient underwent total hip arthroplasty with tantalum augment, (D): Intra op fixation of acetabular defect with total hip and metal augment, (E): follow up after 2 years

DISCUSSION

In revision total hip arthroplasty, acetabular defect reconstruction can be difficult. Revision surgery is successful if the implant is press-fit into the bone, bony deficiencies are bridged, and the hip's center of rotation is restored [9]. Stability can be adequately achieved with an appropriate shell alone in patients with small oval defects, and stability can be achieved with jumbo components in cases of bigger oval defects.[10].

Other methods include using a combination of allografts with cemented shells, rings, cages, shells with a high center of rotation,10 cup-cage structures, and elliptical shells. However, osseous fixation can be hampered by insufficient primary stability and host-bone contact of 50%, which might result in early failure [11].

Tantalum has been shown to have great osseointegration capabilities and high biocompatibility, according to a recent study. A pad made of tantalum can be used to replace large bone abnormalities, and the metal can also be utilized to provide prosthetics with long term stability [12].

In the current study we found that the study population mean age was 50 ±12, 33.3% of them were found males.

Kong et al. [13] stated that among 38 cases, age at surgery was on average 67.5 (range: 48.0-84.7), and patients were followed for an average of 7.3 years. There were 5 patients who died of unrelated reasons but had at least 6 years of follow-up data. Surgery was performed for aseptic loosening in 34 cases (89.5%); the remaining 4 (10.5 %) cases required a two-stage revision due to a deep infection. Eachempati et al. [14] reported that the average age was 62.5 (range: 34-85), there were 22 male and 23 female patients, and the patients were followed for an average of 75 months (54 to 125). Fifty percent of the hips had Paprosky type IIIA defects, 14 had type IIIB defects, 6 had type IIC defects, and 4 had type IIB defects. Pelvic discontinuity (PD) was not present in any of the patients.

In the current study we found that as regards Paprosky classification 25% of patients 2A, 58.33% with 3A, 8.33% with 3B and 8.33% with 2C. In agreement with our findings, Abolghasemian et al. [15] reported that two cases with a Paprosky type IIIA defect and two patients with a Paprosky type IIIB defect and subsequent PD experienced acetabular component failure. Poor initial fixation was clearly the cause of loosening in both individuals with type IIIA defects. One happened after four days of surgery. The other case did not include screw fixation until 18 months after surgery and involved introducing the shell in a "flying buttress" position.

Ansorge et al. [16] stated that for significant, uncontained defects, primarily of the Paprosky Types 3A and 3B, they typically used a mix of trabecular metal augments and revision shells as therapy of choice. In their study, this method was simple, consistent, and has been shown to produce excellent clinical and radiographic outcomes at 2 to 5 years follow-up.

Malahias et al. [17] noted according to the Paprosky classification, type 3 acetabular bone defects accounted for the vast majority of cases (type 2A in 58 cases, 7.2 percent; type 2B in 139 cases, 17.2 percent ; type 2C in 72 cases, 8.9 percent ; type 3A in 360 cases, 44.7 percent ; and type 3B in 177 cases, 22.0 percent). At mean mid-term follow-up, the revision rate for 769 acetabular revisions with augments was 5.7% (46 patients). Dislocation (3.3%) was the most common cause of revision followed by, periprosthetic joint infection (accounted for 2.9%), and finally aseptic loosening (accounted for 2.7%).

In the current study Regarding preoperative characteristics, the mean WOMAC function 34.85 ± 16.5, the mean of WOMAC stiffness was 42.2 ± 14.63, the mean WOMAC pain was 48.6 ± 18.7, the mean WOMAC global was 34.31 ± 10.04, the mean Oxford score was 33.33 ± 13.39, the mean SF-12 physical component was 26.95 ± 8.61 and the mean SF-12 mental component was 45.99 ± 15.04.

Our findings agreed with Migaud et al. [18] who reported that quality-of-life (WOMAC, Oxford Hip Score, SF-12) data at baseline from 26 of 32 patients who still had their implants in place after the follow-up period. After at least 24 months, quality-of-life data were collected from all 32 patients whose initial cup-augment construction was still in place. Except for three patients who died recently before the 2-year follow-up period was through, one who had a previous revision with a new cup-augment build, and one who had already underwent re-revision for a failed augment, this represents the whole patient population. Most patients had very good or exceptional outcomes in terms of hip function and overall quality of life, and their quality-of-life scores improved significantly from preoperative baseline.

Also, Lingaraj et al. [19] noted that the average postoperative SF-12 score was 43.5 (range: 21 to

56), with the mental component averaging 51.2 (range: 37 to 61), indicating higher mental health than the average American. This disparity may be due to population and cultural differences.

Banerjee et al. [20] illustrated that the mean OHS, and WOMAC global score were 76 and 79 respectively. The average scores for the SF-12 physical and mental components were, respectively, 39 and 52. Seventeen patients who were followed up in the clinic or through telephone but did not fill out the entire outcome questionnaire reported no problems with function or pain.

In the present study we found that Regarding preoperative UCLA satisfaction scores, it was fond that the mean function score was 73.25 ± 3.78, the mean pain Score was 79.0 ± 11.04, the mean Recreational Score was 76.31 ± 7.03, the mean overall Score was 93.29 ± 5.32 and the mean Total Score was 80.13 ± 9.08, there was highly significant improvement after treatment (p<0.01), according to quality of life after treatment.

In accordance with our findings, Jenkins et al. [21] reported that functional outcomes (mean WOMAC score function 88.3 (31.9 to 100), mean OHS 89.2 (31.8 to 100)) and pain alleviation (mean WOMAC score pain 90.5, (38.3 to 100)) were both excellent. The percentage of satisfied patients was very high. Also, Kavalerskiy et al. [22] reported that Eight patients (nine hips) experienced severe pain before surgery, eight had moderate discomfort, eight had light pain, four had no pain, and two had no pain at all. Twelve patients (13 hips) reported no pain after surgery, nine reported mild pain, and one had strong pain. Five patients did not need a walking aid prior to surgery, three need a stick for extended walks, and twelve required full-time help with a walking frame or crutches. Two patients went into surgery unable to walk. Eight patients were able to walk without assistance after surgery, four required a walking stick for longer distances, and ten required constant assistance from a walking frame or crutches. After surgery, 100% of patients were able to walk.

In the current study we found that there were highly significant improvement of the UCLA Satisfaction scores after treatment (p<0.01). In agreement with our study, Zhen et al. [23] reported that UCLA and the average Modified Harris Hip Score (mHHS) preoperatively were and 2.6 ± 0.7 (ranging from 2 to 4) and 44.1 ± 4.0 (ranging from 35 to 50), respectively and at the last follow-up were 7.3 ± 0.5 (ranging from 7 to 8) and73.7 ± 4.2 (ranging from 68 to 85), respectively. In particular, the average postoperative SF-36 score was significantly higher than the preoperative score in the bodily pain category (P <0.05), and the average postoperative UCLA score increased from 2.6 (ranging from 2 to 4) to 7.3 (ranging from 7 to 8) as compared to the preoperative score of 2.6 (ranging from 2 to 4).

This finding agreed with that obtained by Ling et al. [24] who stated that Revision total hip arthroplasty (RTHA) was associated with a significant rise in the UCLA activity score (p <0.001): Thirty-seven percent showed an increase in their UCLA activity score, while fifty percent showed no changes; forty-nine percent participated in at least moderate levels of exercise (UCLA score 6). Scores on the UCLA Activity Scale Prior to Surgery, (p< 0.001) long-term UCLA performance was independently predicted.

In agreement with our findings, Agarwala et al. [25] noted that Implant satisfaction was quite high at 12 months for both groups (97/100 for the preference group and 93/100 for the randomised group). Similar progress up to 12 months (p <0.001) was seen on the HHS, OHS, and UCLA, all of which were comparable at baseline.

Our strength point that when used augment which is cementless and give advantage that it have longer durability and less complications.

Limitations:

The limited sample size, which means that more research is needed to confirm our findings. Ideal would-be comparison with results of other types of reconstruction, such as allografts from the same institution. This technique, in our hands, is relatively straightforward, reliable, and associated with very good clinical and radiographic results at 2 years follow-up. We await longer-term follow-up as well as additional reports from other centers to validate our early outcomes with this new reconstructive regimen.

CONCLUSION

Satisfactory clinical as well as radiographic outcomes were obtained by modular Tantalum Augments for the reconstruction of acetabular defects in Total Hip Arthroplasty. This approach increases the rate of stable fixation.

Conflict of interest: None.
Financial disclosure: None.

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