

Early Results of Femoral Reconstruction with a Tapered, Cementless, Modular Stem

*Jihad M. Al-Ajlouni FRCSI (Orth & Trauma)*¹*

Abstract

Objective: The orthopedic surgeon is faced with various challenging problems on the femoral side while performing a revision total hip arthroplasty. Some of these challenges may arise acutely or even intra operatively with limited resources. The aim of this study is to evaluate clinical and radiological outcomes with a single revision modular system used for various indications, and to determine whether such a system achieved initial fixation, femoral offset restoration, stability, and leg length equalization.

Methods: We prospectively followed 33 patients with 36 implants for various indications. Functional assessment was achieved using the Harris hip score (HHS). Hip stability, Leg length discrepancy, stem fixation, and offset restoration were evaluated radiographically. Follow up ranged from 24-87 months.

Results: HHS increased from a preoperative mean of 22.1 to a mean of 71.6 postoperatively. The total number of patients who had dislocation is 5 (13.9%). Three stems were re-revised (9%). Subsidence of the femoral component was less than 5mm in 30 patients (83%). Leg length discrepancy was corrected to within 5mm in 53% of patients, Offset restoration was achieved in 39% of patients. No fractures at the body to stem junction were seen at latest follow up.

Conclusions: Modular femoral stems are useful to address hip stability, leg length equalization, offset restoration, and distal fixation when revising a failed femoral component in the presence of significant proximal femur bone loss. These stems provide good clinical outcome in a simple, uniform, reproducible way.

Keywords: Revision total hip replacement, Modular femoral stem, Cementless fixation, Femoral bone loss, Leg length discrepancy after total hip replacement.

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Introduction

Total Hip Arthroplasty (THR) offers a reliable treatment option that relieves pain and improves function. Total hip replacement (THR) is an extremely cost-effective treatment

intervention⁽¹⁾. It has been estimated that hip arthroplasty will increase by 174% from 2005 to 2030, with 572,000 operations expected by the latter year in the United States⁽²⁾.

The indications for surgery are expanding and more hips are implanted in younger

1. The Department of Orthopedic Surgery, Faculty of Medicine, The University of Jordan, Amman, Jordan.

* Correspondence should be addressed to:
E-mail: jajlouni@hotmail.com

patients. It is expected that more and more hips will need revision.

In performing revision THA, the aim of the surgeon is to obtain a stable durable component fixation and to restore joint kinematics. Challenges on the femoral side include bone loss secondary to loosening, infection, failure of fracture fixation, periprosthetic fracture, acute fracture with arthritic joint, or deformity. Some of these challenges can be dealt with by a conventional or a non modular revision stem. Sometimes, the proximal bone loss is extensive that you need to rely on distal fixation. Also the need for distal fixation may rise intra operatively in cases of intra operative fracture with severe osteolysis, or infection, or while extracting a well fixed stem.

Modular femoral components were developed to address concerns with offset which is important for muscle strength and function, leg length discrepancy, and instability. They have the potential to make the surgical procedure easier by addressing these concerns at the same time but independent of each other.

We present our experience with one system used for 33 patients with different indications. The aim of this study is to evaluate clinical and radiological outcomes with a single revision modular system used for various indications, and to determine whether such a system achieved initial fixation, femoral offset restoration, stability, and leg length equalization.

Materials and Methods

In the period from June 2005 to September 2010, a total of 36 ZMR stems (Zimmer Inc., Warsaw, IN.) (Fig.1) were implanted for 33 patients (3 patients had further revision with the same design, no bilateral cases) by a single

Orthopaedic Surgeon. The mean age was 66.4years (range 28 – 94). Eighteen patients were men and 15 patients were women.



**Figure 1. ZMR stem and the cone body
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In four hips this was the first operation, in 16 the second, in 11 the third, in 3 the fourth, in one the sixth, and in one the seventh operation. Indications for the operation are listed in Table 1.

The operation was done acutely for 11 patients (30.5%), and electively in 25 patients (69.5%). one patient died in the immediate perioperative period, and six patients died more than one year after the operation due to unrelated causes. The follow-up ranged from 24-87 months, a mean follow up of 46 months. There were no other patients lost to follow up.

We had prior Institutional Review Board approval to conduct this study.

Pre-revision femoral defects were classified according to the system of Bohm and Bische[³]. It divides the femur into fourths and characterizes the distal most extent of bone loss and proximal-most extent at which fixation is possible. The Bohm-Bischel classification is described in Table 2.

Periprosthetic fractures were classified according to Vancouver Classification, proposed by Duncan and Masri⁽⁴⁾. It is based primarily on the location of the fracture, the

quality of fixation of the stem, and the quality of the bone⁽⁵⁾. Five of our cases were B2, and two cases were B3.

Table 1: The indications for the operation

The Indications for the operation:		percentage
1. Developmental Hip Dysplasia with high dislocation.	1 case	2.8%
2. Deformity With previous femoral osteotomy.	1 case	2.8%
3. Acute hip # with hip OA.	4 cases	11%
4. Femur neck fracture with intramedallary nail.	1 case	2.8%
5. Failed I.F.	7 cases	19.4%
6. Revision , include :	22 cases	61.1%
a) Infection. (one case complicated by periprosthetic fracture)	5 cases	
b) Loosening. (one case complicated by periprosthetic fracture)	7 cases	
c) Dislocation.	4cases	
d) Cortical perforation.	1 case	
e) Periprosthetic fracture.	5 cases	

Table 2. Bohm and Bischel Classification of Femoral Defects

Type	Description	Ratio	Percent
1A	Damage limited to proximal 25% of femur and fixation still possible in proximal 25%	7/36	19.4%
1B	Damage limited to proximal 25%, but fixation possible only in 2 nd quadrant	2/36	5.5%
2A	Damage extends to 2 nd quadrant but fixation still possible at same level	11/36	30.5%
2B	Damage extend to 2 nd quadrant and fixation possible only in third quadrant	5/36	13.9%
3A	3 rd quadrant damaged; fixation possible at same level	6/36	16.7%
3B	3 rd quadrant damaged; fixation possible only 4th quadrant	4/36	11.1%
4A	4th quadrant damaged; fixation possible in 4th quadrant	1/36	2.8%
4B	4th quadrant damaged so extensively that fixation not possible with standard implant	0/36	0.0%

We used the tapered ZMR stem in all cases. The system provide a stem with a consistent 3.5° taper geometry over the distal 105 mm of

the stem which promotes axial load transfer and resistance to subsidence while splines provide rotational stability. Three stem

lengths, 135mm, 185mm, and 235mm are offered in eight diameters (14-22 mm), and we used the cone body design in all cases. The Cone Body addresses those situations where maximum version control is necessary. 28mm head was used in 26 (72%) patients, and 32mm head was used in 10(28%) patients. The bearing surface was metal (Cobalt-Chromium) on polyethylene.

The operations were performed under general anesthesia in 75% of the operations, and spinal anesthesia in 25%. All patients were put on the lateral position, and we used the antero-lateral approach for the infected cases. Anterolateral approach with extended trochanteric osteotomy was used for other revisions and anterolateral approach with extended trochanteric osteotomy through the fracture site in acute fractures and in cases of failed internal fixation with splitting of the proximal segment.

In most cases, the revised femur previously had a cementless stem. We used a prophylactic circulage wire around the distal femur which was reamed to a tapered cone with conical reamers. From the reaming, a trial stem was selected to achieve stability distally, where as a proximal segment was chosen to optimize leg lengths and stability throughout a range of motion.

Stability of the stem was achieved via wedging of the stem in the femur proximally (metaphysis intact), or distally (metaphysis deficient) or both. The actual prosthesis was then preassembled and implanted.

The acetabulum was revised at the same time in all cases. Constrained liner was used in 10(28%) patients. Tissue and bone cultures were obtained from all patients with previous operations.

All patients received prophylactic perioperative antibiotics. Five patients who

had the operation for infected total hip arthroplasty had a two stage revision. Ancillary autogenous or allogenic bone graft was not used in any case. Postoperatively, pain was controlled with opiates and NSAIDs. Patients were mobilized the day after surgery, with protected weight bearing when practical.

Patients were followed with clinical assessment and radiographs preoperatively, at 6 weeks, 3 months, 6 months, 1 year, and annually thereafter by the same physician.

Clinical assessment was done using the Harris Hip Score HHS⁽⁶⁾. We obtained standard anteroposterior [AP] view of the pelvis, and AP and lateral views of the affected hip. The immediate postoperative series of radiographs served as the baseline with which all subsequent radiographs were compared.

Subsidence was determined by measuring the distance between a fixed point on the stem, usually the body-stem junction, and a fixed point on the femur (the lesser trochanter if available). A difference of 5 mm or more in the measured distance between the immediate postoperative radiograph and the radiograph taken at last follow up was considered as subsidence^(7,8).

Postoperative offset was measured on the AP view as the distance from the center of rotation of the head to the axis of the femoral shaft at 90 degrees Fig.2. It was considered correct if it was within 2 mm of the opposite side.

Leg length correction was also measured on the AP view by measuring the distance from the lesser trochanter to a horizontal line based on the ischial tuberosity Fig.3. It was considered correct, if it was within 5 mm of the other side.

The Statistical Package for Social Sciences (SPSS, version 19) was used to analyze data. Data were described using means and

percentages. Wilcoxon signed-rank test was used to test the significance of change in the Harris hip score before and after surgery. A p-

value of less than 0.05 was considered statistically significant.

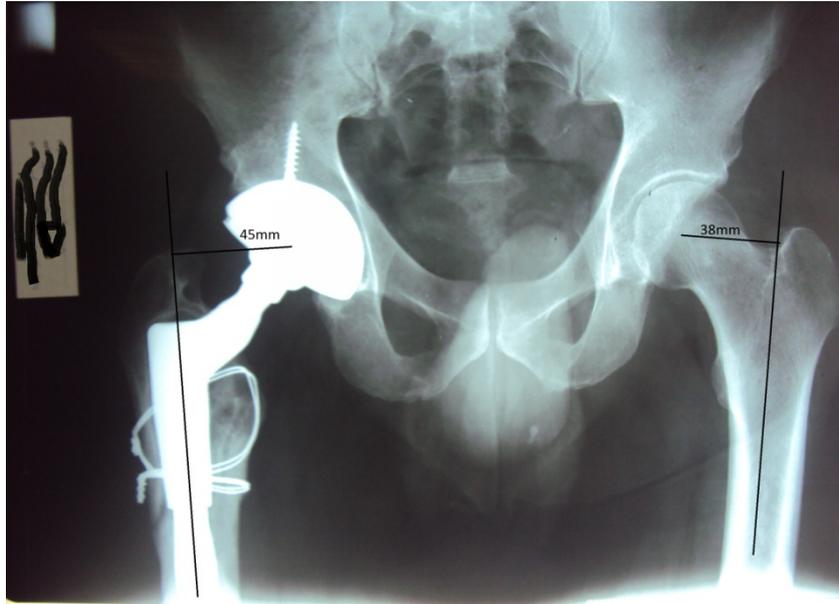


Figure 2. An AP radiograph illustrates measurement of the offset on both sides

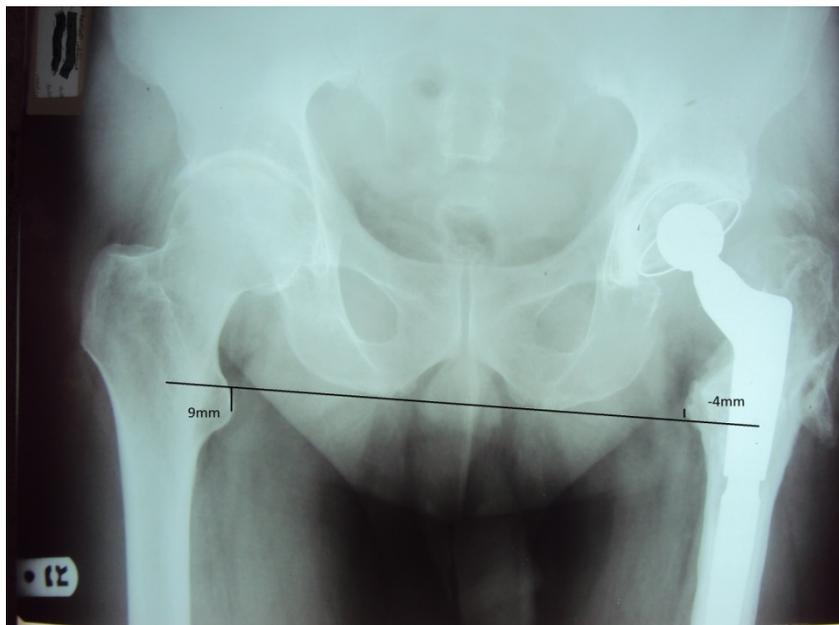


Figure 3. An AP radiograph illustrates measurement of postoperative leg length discrepancy

Results

The Harris hip score (HHS) ranged from

zero to 65 preoperatively and from 32 to 95 postoperatively. The HHS improved from a

preoperative mean of 22.1(Standard deviation 22.6) to a mean of 71.6 (standard deviation 21.6) postoperatively. Sixteen patients (44.4%) achieved a score of 80 or more. Seven patients (19.4%) were able to walk without any walking aid.

Three stems were re-revised (9%). One for subsidence and recurrent dislocation, he has three previous operations for subtrochanteric fracture treatment and has 2b bone defect. He was treated with a larger diameter stem and a constrained liner and subsequently stabilized with no evidence of loosening or subsidence. His last post operative HHS is 85. The second stem was revised 3 days postoperative, due to lateral cortical perforation and impending fracture with a longer stem. His HHS during the last follow up was 92 with no evidence of subsidence. The third stem was revised 3 weeks after the second stage revision for infection with a larger stem and a constrained liner because of subsidence and dislocation she had six previous operations for fracture treatment and failed arthroplasty, and she had type 3b bone defect. This patient had recurrent infection which was treated with antibiotic suppression for 6 months, and subsequently excision arthroplasty was done to control infection. Her HHS is 32.

Three more patients had dislocation. One patient had single episode of dislocation which was reduced and subsequently stabilized. His HHS is 70. The second patient had two episodes of dislocation which were reduced with no recurrence for the last year and his HHS is 76. Another patient had recurrent dislocation for which a cup revision with a constrained liner and a larger head was done with no recurrence or dislocation for the last 22 months. His HHS is 60.

The total number of patients who had dislocation is 5 (13.9%). And all of them had

the operation for failed internal fixation and had multiple previous operations (in 3 the 3rd in one the forth and in one the sixth operation) with significantly compromised soft tissues, two patients stabilized with close reduction and one patient had acetabular revision with constrained liner and no dislocation for the last year of follow up.

The other two patients who had dislocation and progressive subsidence had significant bone loss and fixation relied only on distal fixation (type 2b and 3b defects). And the problem of dislocation was solved with constrained liner.

One patient had persistent pain and developed early, after 2 years, cup loosening presumably due to infection and she is refusing any surgical intervention. Her HHS is 55.

Of the five patients who had 2-stage revision for infected arthroplasty, the infection was not controlled in only one patient (20%). None of our patients had nerve injury, or heterotopic ossification. The average preoperative Hb was 11.4, and blood transfusion was needed in 34 procedures (94%). Other medical complications included acute renal failure (2.8%), CVA (2.8%), Hemolytic anemia (2.8%), Sigmoid colon volvulus (2.8%), Non fatal P.E. (2.8%), and fatal M.I (2.8%).

There was no evidence of osteolytic lesions around any stem. Subsidence of the femoral component was less than 5mm in 30 patients (83%) and averaged 1.33 mm (rang 0-10mm), Fig.4. Two patients had subsidence of 6mm during the first year which was stabilized spontaneously with no clinical significance. Three patients had subsidence of 8mm, one of them had recurrent dislocation and treated with revision of the stem using a larger stem and constrained liner. The other two were stabilized without any clinical significance.

One patient had progressive subsidence of 10 mm within the first month with dislocation, and treated with revision. As such, the mechanical failure rate due to subsidence of

the stem was 5.5% (2 out of 36) and both of them had significant proximal bone deficiency and fixation relied on distal fixation only.

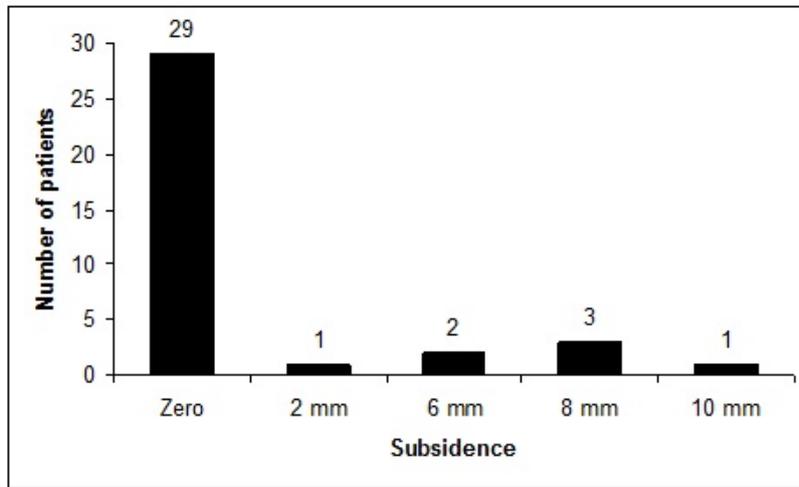


Figure 4. A graph showing the degree of subsidence in the study group. Eighty three percent of the patients had 5 mm or less of subsidence

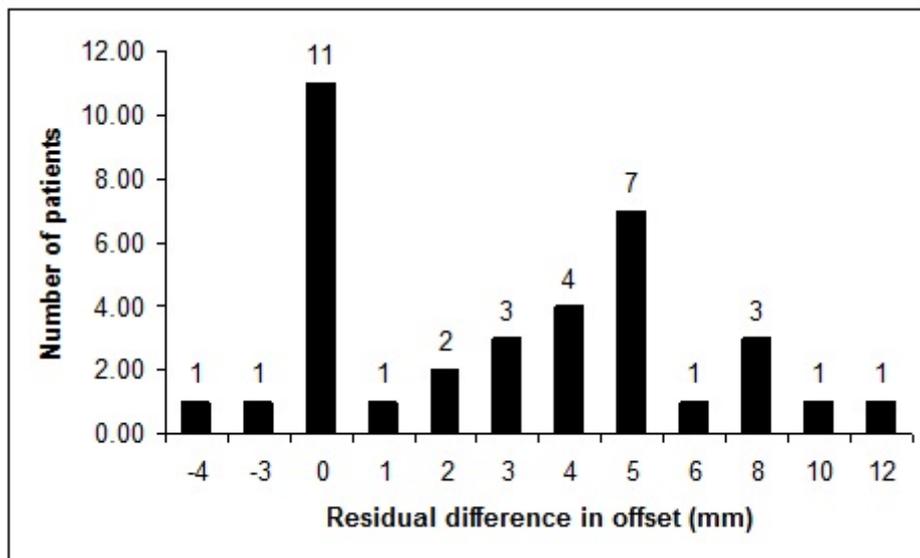


Figure 5. A graph depicts the degree of residual difference in offset in the study group

Offset restoration within 2mm compared with the contra lateral side was achieved in 14 patients only (39%) Fig. 5.

Leg length discrepancy was corrected to

within 5mm in 19 patients (53%), Fig.6, and within 12mm in 33 patients (92%), none of the patients had lengthening on the operated side, and all patients had improvement compared to

preoperative leg length discrepancy.

We had no stem fractures with a mean

follow up of 46 months in spite of severe defects in our series.

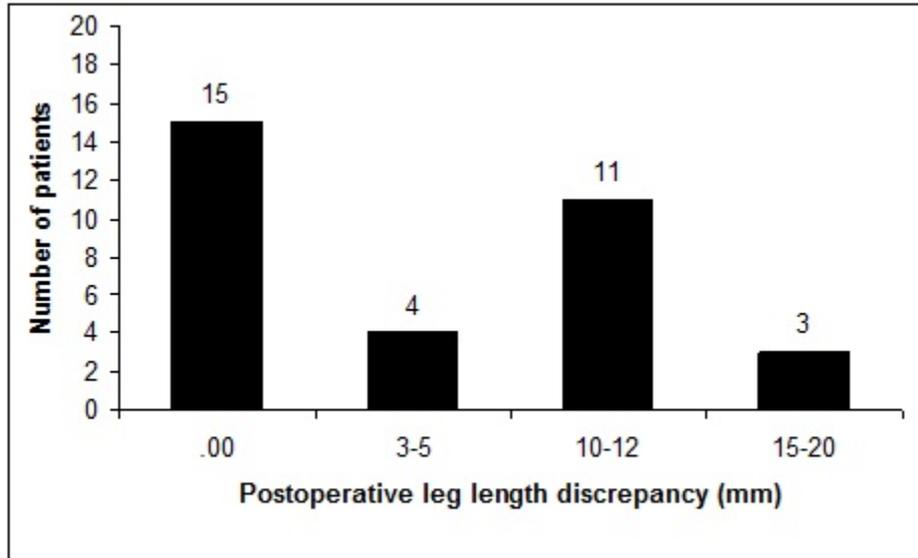


Figure 6. A graph showing the degree of post operative leg length discrepancy in the study group. Leg length was corrected to within 5mm in 53% of the patients. None of the patients had lengthening

Discussion

Femoral reconstruction in revision THA may be challenging in the presence of significant bone loss and/or deformity. Modularity allows surgeons to achieve correction of leg length discrepancy, offset restoration, and stability independent of distal fixation. The ZMR taper stem is a versatile modular system that allows distal or, extensive proximal and distal, fixation and versatile proximal reconstruction. Previous reports presented encouraging results using this system⁽⁸⁻¹⁰⁾. The aim of our study was to evaluate clinical and radiological outcomes with a single revision modular system used for various indications, and to determine whether such a system achieved initial fixation, femoral offset restoration, stability, and leg length equalization.

Results of cemented femoral components in

revision THA were not encouraging, with failure rates of 17% to 60% at 2 to 8 years of follow up⁽¹¹⁻¹²⁾.

Alternate solutions for revision of the bone-deficient femur, including impaction grafting, megaprosthesis and proximal femur allograft are technically demanding and have had high complication rates^(13,14).

During the last three decades several different concepts of cementless revision stems have been introduced and used successfully. Tapered stems are designed according to the principles of the Wagner SL stem (Sulzer Orthopedics Ltd, Baar, Switzerland), with conical geometry for distal axial stability and three-point fixation and longitudinal splines for rotational stability^(8, 15).

Modularity offers the potential advantage of adjustment and restoration of leg length, offset, version, and proximal fill. These

advantages have not been clearly shown in comparative studies^(16, 17). Disadvantages of stem modularity include the risk of stem fractures, fretting, and higher cost⁽¹⁶⁻¹⁸⁾. Survival of various distal fixation stems at 5 to 10 years is consistently approximately 95%, with no clear superiority of any specific design^(8, 19-24). Earlier experience with the ZMR system was encouraging. Sporer and Paprosky⁽¹⁰⁾ reported the short-term outcome of 11 ZMR taper stems used for severe segmental bone defects, with only one failure related to infection. Kang et al.⁽⁸⁾ reported 2 to 5 years' follow up of 39 ZMR stems, mostly porous, with only one revision related to subsidence and instability. Lakstein et al.⁽²³⁾ had a 93.8% survival rate of the ZMR porous stem at 10 years.

The surgeon aims to get secure initial fixation of the femoral component, which will hopefully translate into secure long term fixation. Subsidence of the femoral component was less than 5mm in 30 patients (83%). Of the six remaining patients, two had progressive subsidence with recurrent dislocation and treated with early revision. Both of them had severe proximal bone deficiency and fixation relied on distal fixation only. Restrepo et al.⁽²⁵⁾ had no mechanical failure in a series of 118 patients with a follow up of 2-7 years; Paprosky et al.⁽²⁴⁾ reported 16% subsidence of non modular porous-coated implants, with stabilization of most during the first 2 post operative years. Unstable subsided stems were revised to larger-diameter stems. Wagner tapered non modular stems were reported to subside more than 5 mm in as many as 48% to 54% of patients, with most stems stabilizing after 3 to 13 months^(3, 15). Subsidence was correlated to stem under sizing, osteoporosis, deficient metaphyseal support, and the use of the transfemoral approach. Under sizing and

osteoporosis are likely responsible for many cases of progressive subsidence.

Leg length and offset restoration play a large role in the functional outcome⁽²⁶⁾. Very little information is available in the published literature regarding these two issues in the modular revision situation. Restrepo et al.⁽²⁵⁾ reported restoration of leg length to within 5 mm in 77% of patients and offset restoration within 2mm in 65% of patients. Our results in this study were restoration of leg length to within 5 mm in 53% and offset restoration to within 2mm in 39% and to within 5mm in 83%. We could not find other comparisons available within the recent published Literature at this time.

Our Dislocation rate of 13.9%, five out of 36 operations, is higher than reported in other series. Restrepo et al.⁽²⁵⁾ reported a dislocation rate of 3%, Park et al.⁽²⁷⁾ 5%, Ovesen et al.⁽²⁸⁾ 6%, Rodriguez et al.⁽²⁹⁾ 10%. All of our patients who had the dislocation had the operation for failed internal fixation and previously had multiple operations and significantly compromised soft tissues.

McInnes et al.⁽³⁰⁾ in their series of 70 patients had a dislocation rate of 10%, 3 of their 7 patients who had dislocation had a femur only revision, in our series all patients had acetabular revision at the same time and we used a constrained liner in 10(28%) patients. Modular stems allow the surgeon to change the offset and maintain the leg length by changing the length of the cone body and the neck length. Also the cone body allows the surgeon to put the stem in any version. The problem of soft tissue compromise from multiple previous reconstructive procedures and disuse muscle atrophy remains a major cause for dislocation. Some additional techniques may need to be implemented to further reduce the incidence of instability.

Mechanical failure due to stem fracture at the modular junction is related to under sizing and significant proximal bone loss. We had no stem fractures with a mean follow up of 36 months in spite of severe defects in our series. Two recent reports had a stem fracture of 1%^(28, 29). Lakstien et al.⁽²³⁾ reported 1 stem fracture after 6 years in a series of 72 patients, and Restrepo et al.⁽²⁵⁾ reported no stem fractures in 118 patients followed up for an average of 4 years. Prevention of this serious complication is achieved by getting proximal fixation or the use of the more recently introduced extra large stems.

We acknowledge limitations of our study. We prospectively collected all data, all patients had the same prosthesis and all surgeries were done by a single surgeon. But the study was not randomized and we had no control group for which we used a different component or different surgical technique to compare and contrast outcomes. Second we only had short term follow up. However, our objectives were met because functional outcome, early

complications, stem fixation, offset and leg length restoration, and stability are evaluated early.

Revision hip surgery may be a complex surgery in an elderly frail patient with multiple medical problems, and the need for this surgery may arise acutely. Modular femoral revision stems like the ZMR stem offers an off-the-shelf solution for various femoral problems in a simple, uniform, reproducible way which addresses the offset, leg length discrepancy, and initial stability independent of each other. This makes the surgical procedure easier and decrease the overall operating time. Longer-term follow up is needed to fully evaluate the ultimate role of these modular revision femoral stems.

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Competing interests: The author has declared that no competing interest exists.

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النتائج الأولية لترميم الجانب الفخذي لمفصل الورك بواسطة مفصل قمعي نمطي بدون اسمنت عظمي

جهد العجلوني¹

1- قسم شعبة العظام والمفاصل، كلية الطب، الجامعة الأردنية

الملخص

الهدف: يواجه جراح العظام الكثير من الصعوبات والتحديات أثناء ترميم مفصل الورك في حالات إعادة الزراعة لمفصل الورك. وبعض هذه التحديات قد تنشأ بشكل طارئ عند حدوث كسر حول المفصل او حتى أثناء إجراء العملية في ظل إمكانيات واستعدادات محدودة. تهدف هذه الدراسة إلى تقييم النتائج السريرية والشعاعية لعمليات أجريت بواسطة استخدام نوع واحد من المفاصل وهو مفصل نمطي (modular) أي يتكون من عدة قطع يمكن تركيبها بطرق مختلفة وقياسات مختلفة لتناسب حاجة المريض، وتعويض ما لديه من نقص قمعي النهائية؛ أي يعتمد على الثباتية عند قسبة عظم الفخذ.

الطريقة: تمت متابعة 33 مريضاً أجريت لهم 36 عملية ترميم لمفصل الورك بطريقة استشرافية لمدة تراوحت من 24 إلى 87 شهراً، وتم الاعتماد على مقياس هاريس للورك لتقييم النتائج السريرية والصور الشعاعية لتقييم ثباتية أجزاء مفصل الورك وثباتية المفصل بعظم الفخذ والقابلية لمساواة طول الطرفين السفليين، والقدرة على تعويض أبعاد عظم الفخذ.

النتائج: لقد تحسن مقياس هاريس للورك من متوسط 22.1 قبل العملية إلى 71.6 بعد إجراء العملية. تعرض 5 مرضى لخلع مفصل الورك بنسبة (13.9%) ونشأت الحاجة إلى عملية إعادة زراعة عند 3 مرضى (9%) من الحالات. غطس المفصل داخل عظم الفخذ بأقل من 5 مم عند 30 مريضاً (83%) وتمت مساواة طول الطرفين السفليين بحدود 5 مم عند 53% من المرضى، ولم يحدث أي كسر للمفصل الصناعي خلال مدة المتابعة.

الاستنتاجات: تشكل هذه المفاصل عوناً كبيراً لجراح العظام أثناء عمليات إعادة زراعة مفصل الورك، ويمكن من توفير ثباتية المفصل وتعويض نقص طول الطرف السفلي وتعويض فقدان أجزاء من عظم الفخذ بطريقة غير معقدة وواضحة قابلة للتطبيق.

الكلمات الدالة: ترميم الجانب الفخذي، مفصل الورك، مفصل قمعي نمطي، اسمنت عظمي.