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ORIGINAL STUDY

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Modular uncemented revision total hip arthroplasty in young versus elderly patients: a good alternative?

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For revision hip arthroplasty, both cemented and cementless techniques have been described for implantation of modular and non-modular implants. Although many articles have been published on non-modular prosthesis, there is a dearth of data on cementless, modular revision arthroplasty in young patients. This study aims to analyze the complication rate of modular tapered stems in young patients below 65 years of age as compared to elderly patients older than 85 years old, in order to predict the complication rate. A retrospective study was performed using a major revision hip arthroplasty center database. Inclusion criteria consisted of patients undergoing modular, cementless revision total hip arthroplasties. Data on demographics, functional outcome, intraoperative, early and medium term complications were assessed. In total, 42 patients met inclusion criteria (<65 years old: 25 patients; >85 years old: 17 patients). For the <65 years old cohort, the mean age and follow-up time was 55.4 ± 9.3 years old and 13.3 ± 13.2 months, respectively. For the >85 years old cohort, the mean age and follow-up time was 87.6 ± 2.1 years old and 4.3±8.8 years, respectively. For intraoperative and short-term complications, no significant differences were observed. Medium term complication is noted in 23.8% (n=10/42) overall, preferentially affecting the elderly group at 41.2% (only 12.0% in the younger cohort; p=0.029). To our knowledge, this study is the first to investigate the complication rate and implant survival for modular revision hip arthroplasty based on age group. It shows that the complication rate is significantly lower in young patients and age should be a consideration in surgical decision making

Keywords: revision; hip; arthroplasty; complication rate; long-term.

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INTRODUCTION

In recent years, the number of primary and revision total hip arthroplasty (THA) has increased steadily, with many surgeons preferring uncemented implants *(1)*. By 2030, it is estimated that up to 572,000 primary and 96,700 revision total hip arthroplasties will be performed *(2)*.

For revision arthroplasty, a surgeon can choose either cemented or cementlesss technique as well as modular versus non-modular prosthesis. Modular THA are barely used for revision arthroplasty and those few studies which have reported on modular THA have shown a 10-year survival between 88% and 95.6% (CI 86-90) *(3)*. Patients over the age of 70 years old showed a lifetime risk of implant failure of up to to 5% compared to those younger than 70 years old facing a 35% (95% CI 30.9-39.1) risk, such as men in their early 50s. When using modular systems, the intraosseuous and extraosseous portions of the femoral recontstruction can be matched, allowing for a greater osseintregration, lower intraoperative fracture rate and less dislocations compared to previous generations of non-modular femoral implants. However, these implants are cost intensive and disadvantages include the risk of mechanical failure which ranges from 7% to 18% in the literature *(4)*. Furthermore, these implants are cost intensive *(5)*.

For patients younger than 65 years old, the median time elapsed between index procedure to revision surgery was 4.4 years *(6)*.Typical complications include infection, length discrepancy, dislocation, periprosthetic fracture, inlay wear, aseptic loosening, and implant failure *(7)*. Modular tapered fluted titanium stems showed good clinical results with a mean Harris hip score of 79 ± 19 after 16 years and an excellent 10-year survival of 97%, although little is known about factors that predict failure *(8,9)*.This study evaluates the effect of age at the time of revision surgery in predicting failures *(10,11)*.

We hypothesize that the complication rate of modular, tapered, cementless stems is lower in young patients as compared to the elderl

METHODS

Our study is a retrospective study conducted using a prospectively-collected database from our major revision hip arthroplasty center. It seeks to investigate patients' outcome, complication rate, and predisposing factors after modular tapered, Revitan revision total hip arthroplasty (Zimmer, Warsaw, IN, USA).

Inclusion criteria include: patients younger than 65 years old, and patients older than 85 years of age at the time of revision THA. Surgeries performed between March 2013 and July 2019 were included. Other data collected about the surgery performed include implant used, surgical approach, need for transfemoral fenestration, use of trochanteric osteotomy, and implant loosening were tabulated *(12,13)*. The surgical approach used were either anterior, anterolateral, lateral, or posterior approach. Additionally, we were interested if any adjunct implants were used such as circumferential femoral cables, cerclages, or plates.

Plain radiographs of the pelvis including Lauensteins' view were obtained. Complications were divided into three categories: intraoperative, early (within 6 months) and medium term (after 6 months). The most common intraoperative complications were femoral shaft fractures. For short and medium term complications, periprosthetic fracture, trochanteric non-union, hip dislocation, implant failure, migration or loosening of implants, heterotopic ossifications, and infection were observed. Radiographic definition of implant loosening and lysis around the femoral stem used was in accordance with the methods presented by Engh et al. *(14)*.

For statistical analysis, IBM SPSS 25 (IBM, Armonk, New York, USA) was used. Linear regression model and multivariate analysis of variance t-test statistical techniques were used. Demographics including age, sex, BMI, length, diameter, and type (straight or curved) of femoral component, size of the neck segment, and presence of an extension sleeve were tested for correlation with complication. The level of significances was set to * p-value ≤ 0.05; ** p-value ≤ 0.01; and *** p-value ≤ 0.005. Furthermore, demographic data

was analyzed for statistical differences by applying the Mann-Whitney U test. In addition, we compared size and type of implants as well as complication rate between the two groups.

RESULTS

In total, 42 revision hip arthroplasty patients met inclusion criteria. Twenty-five patients belong to the group that is age 65 years old or younger. Seventeen patients exceeded the age of 85 years. The mean age and follow up time for the younger group was 55.4 ± 9.3 years old and 13.3 ± 13.2 months, respectively; whereas the older group was 87.6 ± 2.1 years old and 4.3 ± 8.8 months, respectively (table II).

In the younger group, the affected hip was almost equally distributed with 14 right hips (n=14/25, 56.0%), whereas in the elderly group the left side was more often affected (n=10/17, 58.8%). Surgical indication was loosening of the primary prosthesis in most subjects, which was more commonly septic in 56.0% (n=14/25) of the young patient and aseptic in 76.5% (n=13/17) in the elderly group. All preoperative demographic findings are summarized in table I.

In total, 3 patients suffered intraoperative complications (n=3/42, 7.1%). For early postoperative complications, the incidence was the same as the intraoperative complications with three cases (n=3/42, 7.1%). Majority of complication were in the group with medium term follow up at 23.8% (n=10/42). In the younger group, the intraoperative complication rate was slightly higher with 8.0% as compared to 5.9%. These included a broken screw and two incidence of profuse bleeding requiring transfusion. No significant difference was observed in the shortterm. In the medium term, the complication rate was significantly higher in the elderly group (12.0% compared to 41.2%; p<0.001).

In the younger cohort, significant correlations from linear regression test were observed between intraoperative complications and transfemoral osteotomy (0.590; p=0.002), number of cerclages (0.444; p=0.026), non union (0.692; p<0.001), one time or recurrent arthroplasty dislocation (0.457; p=0.022, respectively, 0.692; p<0.001) (see Tabel V). In the older cohort, significant correlations were found for hospitalization (0.573; p=0.016), transfemoral and trochanteric osteotomies (0.685; p=0.002, respectively 1.000; p<0.001). (Table III and VI)

For early complications in the younger cohort, positive correlations were identified for transfemoral osteotomy (0.431; p=0.032), trochanteric cerclage (0.431; p=0.032), anemia (0.846; p<0.001), one time or recurrent dislocation (0.799, respectively 0.553; p<0.001 and p=0.004), and periprosthetic fracture (0.553; p=0.004). Since only one patient

Table I. — Summary of basic demographic data at the time of revision THA

	Total	Young	Elderly	p-value
Numbers (%)	100.0; n=42	59.9; n=25	40.5; n=17	
Gender, female (%)	64.3, n=27	64.0, n=16	64.7, n=11	**0.968**
Mean age (years)	68.5±17.4	55.4±9.3	87.6±2.1	**<0.001**
Left hip (%)	50.0, n=21/42	44.0, n=11/25	58.8, n=10/17	**0.126**
Aseptic loosening (%)	57.1, n=24/42	44.0, n=11/25	76.5, n=13/17	**0.038**
Septic loosening (%)	42.9, n=18/42	56.0; n=14/25	23.5, n=4/17	**0.038**
Girdle Stone situation (%)	35.7, n=15/42	48.0, n=12/25	17.6, n=3/17	**0.045**

Table II. — Clinical follow up

	Total	Young	Elderly	p-value
Follow up (months)	9.8±12.6	13.3±13.5	4.3±9.0	**0.023**
Hospitalization (days)	17.0±8.95	15.5±8.84	19.2±8.91	**0.197**

Table III. — Intraoperative findings, treatment and complications

	total	young	elderly	p-value
Anterolateral approach (%)	23.8, n=10	12.0, n=3	41.2, n=7	**0.029**
Lateral approach (%)	33.3, n=14	36.0, n=9	29.4, n=5	**0.666**
Posterior approach (%)	38.1, n=16	48.0, n=12	23.5, n=4	**0.068**
Stem diameter (mm)	**17.7**±2.0	17.7±1.9	17.6±2.3	**0.960**
Distal stem length (mm)	173.3±37.2	176.8±37.4	168.2±36.3	**0.476**
Proximal stem length (mm)	72.9±14.3	71.6±13.7	74.7±15.0	**0.503**
Cup stability (%)	40.5, n=17	28.0, n=7	58.8, n=10	**0.047**
Cup exchange (%)	59.5, n=25	76.0, n=19	35.3, n=6	**0.007**
Straight stem (%)	85.7, n=36	88.0, n=22	82.4, n=14	**0.618**
Curved stem (%)	14.3, n=6	12.0, n=3	17.6, n=3	**0.618**
Metal femoral head (%)	52.4, n=22	44.0, n=11	64.7, n=11	**0.196**
Ceramic femoral head (%)	42.9, n=18	48.0, n=12	35.3, n=6	**0.426**
Short (%)	33.3, n=14	32.0, n=8	35.3, n=6	**0.829**
Middle (%)	26.2, n=11	28.0, n=7	23.5, n=4	**0.754**
Long (%)	31.0, n=13	32.0, n=8	29.4, n=5	**0.863**
Extralong (%)	9.5, n=4	8.0, n=2	11.8, n=2	**0.692**
Cable cerclage greater trochanteric (%)	21.4, n=9	20.0, n=5	23.5, n=4	**0.791**
Cable cerclage femur (%)	83.3, n=35	76.0, n=19	94.1, n=16	**0.128**
Transfemoral osteotomy (%)	17.7, n=7	20.0, n=5	11.8, n=2	**0.800**
Fenestration (%)	7.1, n=3	8.0, n=2	5.9, n=1	**0.230**

suffered from early complications in the older cohort, no linear regression model could be applied. All findings are illustrated in table VI.

For the younger cohort, similar correlations were observed for trochanteric cerclage (0.431; p=0.032), anemia (0.510, p=0.009), one time and recurrent dislocation (0.799 vs. 0.553; p<0.001, respectively p=0.004) as well as periprosthetic fracture (0.553; p=0.004) (table V). In the elderly cohort, only a significant negative correlation for implant survival (-0.764; p=0.045) was identified. (Table IV)

DISCUSSION

In end-stage degenerative joint diseases, THA is a successful procedure for many patients, but not without risks. In recent years, the number of revision hip surgery performed has steadily increased and is estimated to reach 96,700 cases by 2030 *(2)*. As primary THA implants are improving, revision surgeries are thought to be predominantly occurring in elderly population and little is known about the functional outcome and complications in younger patients who need revision THA.

In monoblock, cementless primary total hip arthroplasty, the mean 5- and 10- year survival is reported at 98.7% and 94.6%, respectively in young patients (<65 years). The results reported in the literature after that initial time period ranges between 27% and 99.5% for 10-14 years. In addition, the complication rate after revision surgery ranged between 2.4 and 16.3% *(15)*. This is comparable to our findings of complication rate of 9.5% for short-term postop and 23.8% for medium term postop.

Since revision arthroplasty is difficult and expensive, a reliable revision implant must be developed to reduce financial burden and to improve functional outcomes *(16,17)*. Furthermore, revision procedures are not typically profitable for most hospital systems, raising the question of who

Table IV. — Intraoperative and postoperative complications

	total	young	elderly	p-value
Intraoperative complications (%)	9.5, n=4	12.0, n=3	5.9, n=1	**0.800**
Intraoperative bleeding (%)	9.5, n=4	12.0, n=3	5.9, n=1	**0.332**
Short term complications (%)	9.5, n=4	12.0, n=3	5.9, n=1	**0.145**
Dislocation once (%)	7.1, n=3	8.0, n=2	5.9, n=1	**0.800**
Medium term complications (%)	23.8, n=10	12.0, n=3	41.2, n=7	**0.029**
Dislocation recurrent (%)	4.8, n=2	4.0, n=1	5.9, n=1	**0.785**
Periprosthetic fracture (%)	7.1, n=3	4.0, n=1	11.8, n=2	**0.350**
Mean subsidence(mm)	0.1, 0.0	0.2±1.0	0.0, 0	**0.416**
Bone modulation (%)	33.3, n=14	36.0, 9	29.4, n=5	**0.218**
Bone formation Gruen Zone 1 (%)	21.4, n=9	28.0, 7	11.8, n=2	**0.218**
Gruen Zone 2 (%)	2.4, n=1	4.0, n=1	0.0, n=0	**0.416**
Gruen Zone 5 (%)	2.4, n=1	0.0, n=0	5.9, n=1	**0.230**
Gruen Zone 7	7.1, n=3	0.0, n=0	17.6, n=3	**0.029**
Bone defect Gruen zone 1	38.1, n=16	56.0, n=14	11.8, n=2	**0.003**
Gruen Zone 2	2.4, n=1	4.0, n=1	0.0, n=0	**0.416**
Gruen Zone 4	2.4, n=1	4.0, n=1	0.0, n=0	**0.416**
Gruen Zone 6	4.8, n=2	4.0, n=1	5.9, n=1	**0.785**
Gruen Zone 7	9.5, n=4	12.0, n=3	5.9, n=1	**0.519**
Non union	2.4, n=1	4.0, n=1	0.0, n=0	**0.416**
Ossification	50.0, n=21	60.0, n=15	35.3, n=6	**0.122**
Ossification with gap >1cm	35.7, n=15	44.0, n=12	23.5, n=4	**0.183**
Ossification with gap <1cm	14.3, n=6	16.0, n=4	11.8, n=2	**0.709**

should pay and who should get this type of surgery, especially if multiple revision surgeries are needed *(16,18)*.

For revision arthroplasty, modular tapered stems allow better and easier adjustment of the lower limb length, forward inclination and eccentricity *(19)*. However, according to the literature, disadvantages include higher incidences of intraoperative fractures, corrosion, and implant failure between the proximal and distal part of the prosthesis *(20)*. Therefore, these implants are primarily used in elderly patients, but there is little known about the expected functional outcome when these implants are used in younger patients.

This cohort analyzed the complication rate of 42 patients, including 25 patients younger than 65 years of age at a mean age of 55.4 ± 9.3 years old. 17 patients in the older cohort included are at a mean age of 87.6 ± 2.1. Surgical indications for most patients in the younger group was septic loosening (56.0%, p=0.038) which was treated with girdle stone procedure (48.0%, p=0.045). In the elderly cohort, aseptic loosening was the most common indication (76.5%, p=0.038). The intraoperative as well as short term complication rate was slightly higher in the younger group at 12.0% versus 5.9% in the older group. For medium term complications, the rate was significantly higher in the elderly group (12.0% compared to 41.2%; p<0.001). Further, heterotopic ossification was observed more frequently in the younger group. This may be confounded by the fact that there is a relatively longer follow up in this group. The linear regression model revealed that the transfemoral osteotomy is

Table V. — Significant correlation between complications for the young group

	Intraoperative complications		Early complications		Medium term complications	
	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
Transfemoral osteotomy	0.590	**0.002**	0.431	**0.032**	0.123	**0.558**
Trochanteric cerclage	0.221	**0.288**	0.431	**0.032**	0.431	**0.032**
Number of cerclage	0.444	**0.026**	0.041	**0.845**	0.041	**0.845**
Anemia	0.676	**<0.001**	0.846	**<0.001**	0.510	**0.009**
Non union	0.692	**<0.001**	-0.075	**0.720**	-0.075	**0.720**
Early complications	0.345	**0.091**	-	**-**	0.621	**0.001**
Medium complications	0.345	**0.091**	0.621	**0.001**	-	**-**
Dislocation once	0.457	**0.022**	0.799	**<0.001**	0.799	**<0.001**
Dislocation recurrent	0.692	**<0.001**	0.553	**0.004**	0.553	**0.004**
Periprosthetic fracture	-0.060	**0.775**	0.553	**0.004**	0.553	**0.004**

Table VI. — Linear regression and correlations between complications and other factors in the elderly

	Intraoperative complications		Early complications		Medium term complications	
	Coefficient	p-value	Coefficient	p-value	Coefficient	p-value
Hospitalization	0.573	**0.016**	-	-	0.329	**0.198**
Implant survival	-	**-**	-	-	-0.764	**0.045**
Transfemoral osteotomy	0.685	**0.002**	-	-	0.065	**0.803**
Trochanteric osteotomy	1.000	**<0.001**	-	-	0.299	**0.244**
Infection	1.000	**<0.001**	-	-	0.299	**0.244**
Anemia	1.000	**<0.001**	-	-	0.299	**0.244**

a risk factor for complication rate in the younger cohort. In the elderly cohort, the transfemoral and trochanteric osteotomies are associated with increased intraoperative complication rate. It is also noteworthy that a significant difference was observed for intraoperative bleeding (young versus elderly patients had a coefficient of 0.676 and 1.000, respectively; $p<0.001$).

Bone defect after stem exchange was most commonly seen in Gruen Zone 1 and 7. This affects the younger patient cohort more frequently. As such, use of extensively porous-coated and circumferentially proximally porous-coated implants have been used to decrease risk of osteolysis *(21)*.

The approach used for revision arthroplasty depends on the primary surgery as well as the surgical indication. In cases where a girdlestone procedure is performed, a posterior approach is favored. For stem exchange in aseptic loosening, we typically prefer anterolateral approach that can be extended to the lateral approach. For periprosthetic joint infection with stable stems, a femoral osteotomy may be required for exaplantation. Intraoperative complications was highly correlated with the use of transfemoral osteotomy (0.590, $p=0.002$), and number of cerclages used (0.444, $p=0.026$). According to the literature, no significant differences in complication rate were found comparing the direct lateral to posterior approach *(22,23)*, some have reported higher complication rates for the anterior approach *(24,25)*.

Furthermore, no significant difference were found in rate of hip dislocation comparing the older versus younger patients. This is consistent with the hip dislocation rate of 0.89% after 5 years as reported in the literature *(26,27)*.Additionally, the revision rate reportedly ranges between 19% and 28.7%, which

was corroborated by our data at 23.8% for medium/long term complications *(28,29)*. We similarly report a lower rate of ossification in Gruen zone 1 and 7 than that was described in the literature (21.4%, respectively 7.1%).

To our knowledge, this is the first study investigating the complication rate of modular, cementless revision THA in young patients under the age of 65 years in relation to an older cohort. Our study shows that modular, cementless revision THA in young patients has a low complication rate and is a good alternative to non-modular ones. However, our study has some limitations. First, the relatively small sample size including only 25 patients in the younger cohort (mean age of 55.4±9.3 years old) and 17 patient in the elderly group (mean age of 87.6±2.1 years old) is limiting. It is also a single-center retrospective design that limits the generalizability of our results. This should be interpreted with appropriate caution. Secondly, due to the short follow up related to the advanced age of some patients can also artificially lower complication rate if the patient expires from other non-orthopedic causes.

CONCLUSION

To our knowledge, this study is the first one to report complication rate and implant survival for modular, cementless revision total hip arthroplasty. Although no significant differences were observed for intraoperative or short-term complications between age groups, medium term complications were significantly lower in younger patients. Further investigations looking at 20 year outcomes with a larger cohort size may shed addition insights on long-term survival.

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