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Research Article

**CONSERVATION REVISION OF TKA ALONG WITH  
METAPHYSEAL METAL DEVICES SLEEVES AND CONES**Ahmad Kamal<sup>1</sup> M.D, Cao Li<sup>1,2</sup> M.D, PhD<sup>1</sup>Department of Orthopedics, The First Affiliated Hospital of Xinjiang Medical University, Urumqi, Xinjiang, China<sup>2</sup>Corresponding author: Cao Li M.D, PhD. Department of Orthopedics, The First affiliated Hospital of Xinjiang Medical University, Urumqi, Xinjiang, China.

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**Abstract:**

**Objective:** Revision total knee arthroplasty is always required after knee periprosthetic fractures and implant loosening. There are many renovation choices available. The aim of our study is to report on conservative renovation option, revision TKA along with metaphyseal sleeves or cone. **Method:** We assessed 22 patients who gone through revision TKA along with a metaphyseal sleeve or porous cone between January 2017 and December 2019. Patients were followed up to period of two years. Patients were evaluated using The Knee Society score at each follow-up. X-rays were taken at 6 weeks, 3 months, and final visit. **Results:** From 22 patients, 16 were belonging to female group and the rest 6 were identified from the male group. The mean age of patients was  $66.95 \pm 11.45$  years ranging from 46-85 years. Majority of patients were females (72.7%). Preoperatively periprosthetic fracture after TKA was diagnosed in 12 patients (54.4%) followed by 5 loosening of prosthesis after primary TKA (22.8%), 4 patients with infection (18.16%) and 1 periprosthetic pain after TKA (4.54%). The mean follow-up was 18 months ranging from 3-35 months. The mean of knee society score was improved from 35 points which range from (10 – 68) preoperatively to 85 (range 50-90) at six week and 90 (range 40-100) at final follow up. The mean Knee Society function scores increased from 25 (range 10- 65) preoperatively to 62 (range 36–100) postoperatively. The average flexion contracture was 6° (range 0°–30°) preoperatively and at the time of the latest follow-up, the average flexion contracture was 3° (range 0°–15°). Mean range of motion was 120° (range 80° to 135°) preoperatively and 115° (range 95° to 140°) post operatively.. There was no significant ( $p > 0.05$ ) correlation of scores with follow-up time. **Conclusion:** From all the outcomes we reached to the conclusion that both cones and sleeves are feasible and executable option for a stable reconstruction of revision TKA after periprosthetic fractures and for aseptic loosening cases with AORI defined type I, type II and type III bone defects.

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**INTRODUCTION:**

Primary TKA is considered as a prosperous procedure in all around the world. It increased the survival of patients and most of the patients satisfy with this procedure<sup>1</sup>. In recent decades the knee arthroplasties (TKA) becomes a wide challenge for whole world, which also boost the revision surgery process day by day<sup>2</sup>. A projection report of USA demonstrates that in 2005 to 2030, the revision total knee would be increased up to 600%. Revision TKA is a complex procedure and its complexity depends on many major elements such as the bone quality and deficiency of osseous tissues<sup>3</sup>. The major aim of revision surgery is to protect the bone, restore bone deficiencies, rescue joint line and most importantly modify the efficacy of soft -tissue balancing<sup>4</sup>. It also helps to manage the most challenging type 2B and 3 bone defects which were classified by Anderson Orthopedic Research institute. Most of the arthroplasties patients belongs to the osseous deficiency and classified in the categories provided by Anderson Orthopedic research institute (AORI)<sup>5</sup>. Most of the patients approximately 42% encountered with the cancellous and cortical metaphyseal bone loss during total knee arthroplasties which caused severe challenge for revision surgeries<sup>6</sup>. With the loss of cortical and cancellous bones, the surgeons faced severe difficulties<sup>7</sup> in primary implant fixation, in bringing back the strength and also in load transfer. In past decades these issues were resolved with stemmed implants; these stemmed implants were cemented in the metaphyseal areas<sup>6</sup>. The success of implants were associated with its stability and fixation which can be acquire with the help of at least three defined anatomical zones of fixation which includes epiphysis, metaphysis and diaphysis<sup>7</sup>. Along with the stemmed implants different surgeons used bone grafts with or without mesh augmentations, allografts, custom- made prostheses and hinged implants as a treatment<sup>7</sup>. But all these procedures had some negative consequences as observed in different researches. Those patients who encountered with structural allograft in revision TKA suffered from different infections (4-8%) and contraction of muscles (8-23%) and need reoperation due to the different complications<sup>8</sup>. The results of hindered implants were quite similar with the allografts and it also caused severe consequences on human health.

To avoid all these risks metaphyseal porous metal devices; cones and sleeves were introduced and gain so much fame in recent years. These devices help to attain better results in short time period<sup>9</sup>. Different studies demonstrate that the metaphyseal sleeves have a major impact on initial implant stability when combining with tibia and AORI type 2 and 3. It is considered as a best source for reconstruction of knee arthroplasty<sup>10</sup>. It enhances

the growth of bone and helps in transformation of stress shielding. Metaphyseal filling implants help in filling the bony defects and consist of two types of implants; tantalum cones and metaphyseal sleeves<sup>11</sup>.

From all above literature this study was planned to check the efficacy of metaphyseal filling implants in a short time period. The aim and objectives of this study was to demonstrate the clinical outcomes of metaphyseal implants and to check the durability of fixation under radiography during conservation revision of TKA with the help of porous metal devices; cones and sleeves.

**MATERIALS AND METHODS:**

From February 2017 to December 2019 , 22 patients with a femoral and/or tibial metaphyseal sleeve or cones implanted during revision TKA at Orthopedic department Xinjiang Medical University. All surgeons were skillful and experienced in complex revision arthroplasty and familiar with the instrumentation system. Patients aged 46-85 years were included in the study. Primary TKA cases were excluded from this study. All patients had follow-up visits and the mean follow-up was 18 months (range 3-35months). All patients were included in survivorship analysis. For this study total 22 patients were selected for revision TKA. 11 had revision with metaphyseal sleeves and the other 11 had cones depending on bone loss classification. Bone loss was assessed characterized from preoperative reports and radiographs according to Anderson Orthopedic Research Institute (AORI) classification. Type 1 was classified as intact metaphyseal bone, Type IIA as more extensive cortical loss of metaphyseal bone with loss of one femoral or tibial condyle, or both condyles as type IIB and type III as deficient metaphyseal bone. Full length radiographs and short length radiography of leg were taken for construction of better analysis. The intraoperative classification of bone defect was done through the trials in which we accessed the appropriate location for metaphyseal device. Method of implant fixation of both stems and sleeves or cones were obtained from preoperative and postoperative radiographs. Knee society score was used for generating outcomes Knee society score were compared with those which were taken before the revision.

**Metaphyseal Sleeves versus Porous Metaphyseal Cones**

The selection between metaphyseal sleeve or cone is not only based on the Anderson Orthopaedic Research Institute (AORI) classification but also on the use of implant system. Sleeves are usually system specific, while porous cones are malleable to any system. Generally metaphyseal sleeves are used, for Type I and Type IIA deformities, while

for Type IIB and Type III deformities cones are used. Both metaphyseal sleeves and cones likely to be used in the more difficult and large bone loss conditions.

### Preoperative assessment

It is important to know the reason of primary arthroplasty failure or the fracture occurred. Most patients present Complaining of pain, instability, and decrease or loss of function. Taking History and physical inspection is important, especially flexion instability. Infections should always be considered as a likely reason of prosthetic failure. The final management of an infected total knee arthroplasty, either in a primary or a secondary exchange, usually needs the use of metaphyseal sleeves and cones, and thus, the operative principles of renovation are similar for both septic and aseptic renovations. However the consequences, will vary due to the potential for reoccurrence of infection. Analysis of preoperative x rays with weight-bearing of different views anteroposterior(AP), lateral, and patellofemoral views should be done. Most TKA revisions requires full-length radiographs from hip to ankle to assess the bones and joints above and below the knee. Sometimes preoperative radiographs are not complete diagnostic for the amount of bone loss and usually underestimate the bone loss defect that is present. Secondary bone loss can also occurs after implant removal. Therefore, intraoperative assessment is the decisive assessment for the surgeons to rule out the cortical and cancellous defects as presented.

### Intraoperative Complications

In poor quality bones the most common intraoperative complication is the fracture when inserting the sleeves or impacting the cone along the stem in the femur or the tibia. Treatment of a fracture may need cerclage wires to provide adequate fixation, and postoperative weight bearing may be reduced to allow early fracture healing.

### Postoperative Management

As primary total knee arthroplasty, revision TKAs are also treated similarly postoperatively, as these patients receive medications as antibiotics, anticoagulation, and physical therapy. The most important postoperative care that varies from primary TKA is weight-bearing status. These implants achieves stable fixation by osseointegration, if weight-bearing precautions are taken. For patients with only tibial sleeves, patients are often allowed to bear weight. Though, patients with femoral sleeves or if the patient's revision knee construct is reliant on sleeve for rotational stability, 50% of partial weight bearing is recommended for 3 to 4 week post-operatively. After that period, patients may weight bear as

tolerated, and followed with serial radiographs to frequently evaluate the position of the component and osseo-integration of the sleeve.

With the help of SPSS 23.0, all the data was placed into this software to analyze the mean median and standard deviation of these two knee society score. Radiograph analysis was used for two purposes. At preoperative stage, radiographic reviews were taken to locate the defect of bone and post-operative radiography were used to analyzed the fracture, alignment of migration of bone and osseointegration.

### RESULTS:

22 patients had gone through the knee revision surgery (Table 1) represents the mean and standard deviation of patient's age, their sex and their indications for revision. From 22 patients, 16 were belonging to female group and the rest 6 were identified from the male group. The average mean of their age was  $66.95 \pm 11.45$  years. The major reasons of revision were aseptic loosening 5 patients (22.8%), 12 periprosthetic fractures(54.4%) ,4 patients with post TKA infections (18.16%) and 1 due to periprosthetic pain 4.54% with osteolysis and instability . 11 patients had revision TKA with extended stem with sleeve and other 11 had revision with cone depending on bone loss which were according to AORI classifications. All patients were followed up to mean 18.3months (range 3-35 months).The mean of knee society score was improved from 35 points which range from (10 – 68) preoperatively to 85(range 55-90) at six week and 90 (range 40-100) at final follow up. The mean Knee Society function scores increased from 25 (range 10- 65 ) preoperatively to 62 (range 36–100 ) postoperatively. The average flexion contracture was  $6^\circ$  (range  $0^\circ$ – $30^\circ$ ) preoperatively and at the time of the latest follow-up, the average flexion contracture was  $3^\circ$  (range  $0^\circ$ – $15^\circ$ ) .Mean range of motion was  $125^\circ$  (range  $80^\circ$  to  $140^\circ$ ) preoperatively and  $115^\circ$ (range  $95^\circ$  to  $130^\circ$ ) post operatively. There was no evidence of loosening or migration of any implant at the final follow-up, and no radiolucent lines were seen between the cones or sleeves and the adjacent tibial and femoral bones at the last follow-up. There was no complications such as infection, loosening, instability of knee joint and fracture nonunion. Three patients with incision exudation were treated with antibiotics for 2 weeks, and the incision healed. Intermuscular venous thrombosis was found by B-mode ultrasonography in 2 patients after operation. Rivaroxaban was taken orally for anticoagulation and the thrombosis disappeared within a month. Fractures healed about 6 months after operation.

**Table 1: Patient Demographics and Indications for Revision TKA.**

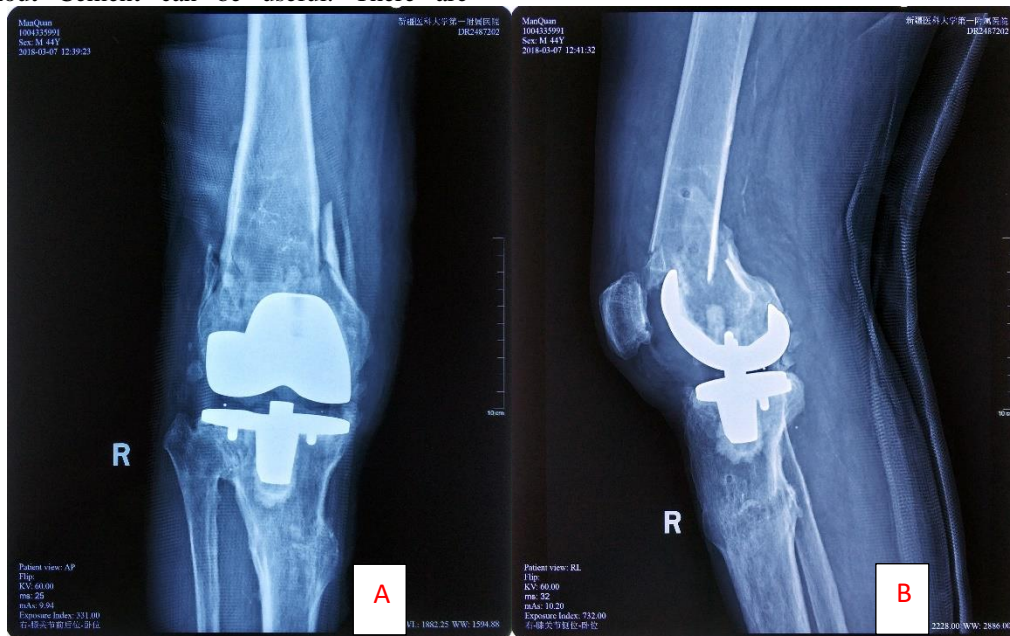
Total Number of Revisions	22
Age	Mean 66.9 years SD 11.45
Female	16 (72.8%)
Male	6(27.2%)
Indication for revision	
Periprosthetic fracture	12(54.4%)
Aseptic loosening	5(22.8%)
Infection	4(18.16%)
Periprosthetic pain	1(4.54%)
Follow-up	Mean 18.3 months Median 18.5 months

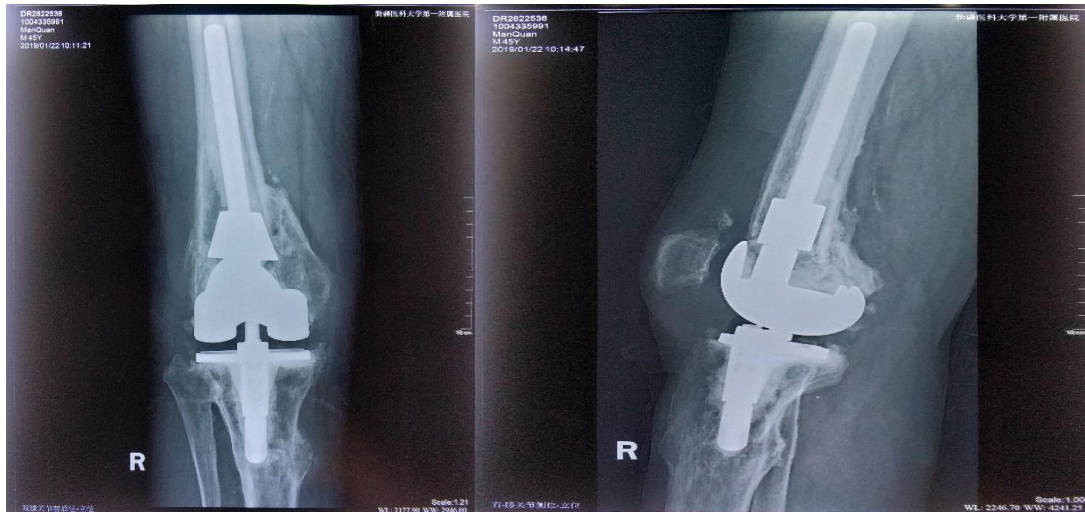
SD, standard deviation; TKA, total knee arthroplasty.

### DISCUSSION:

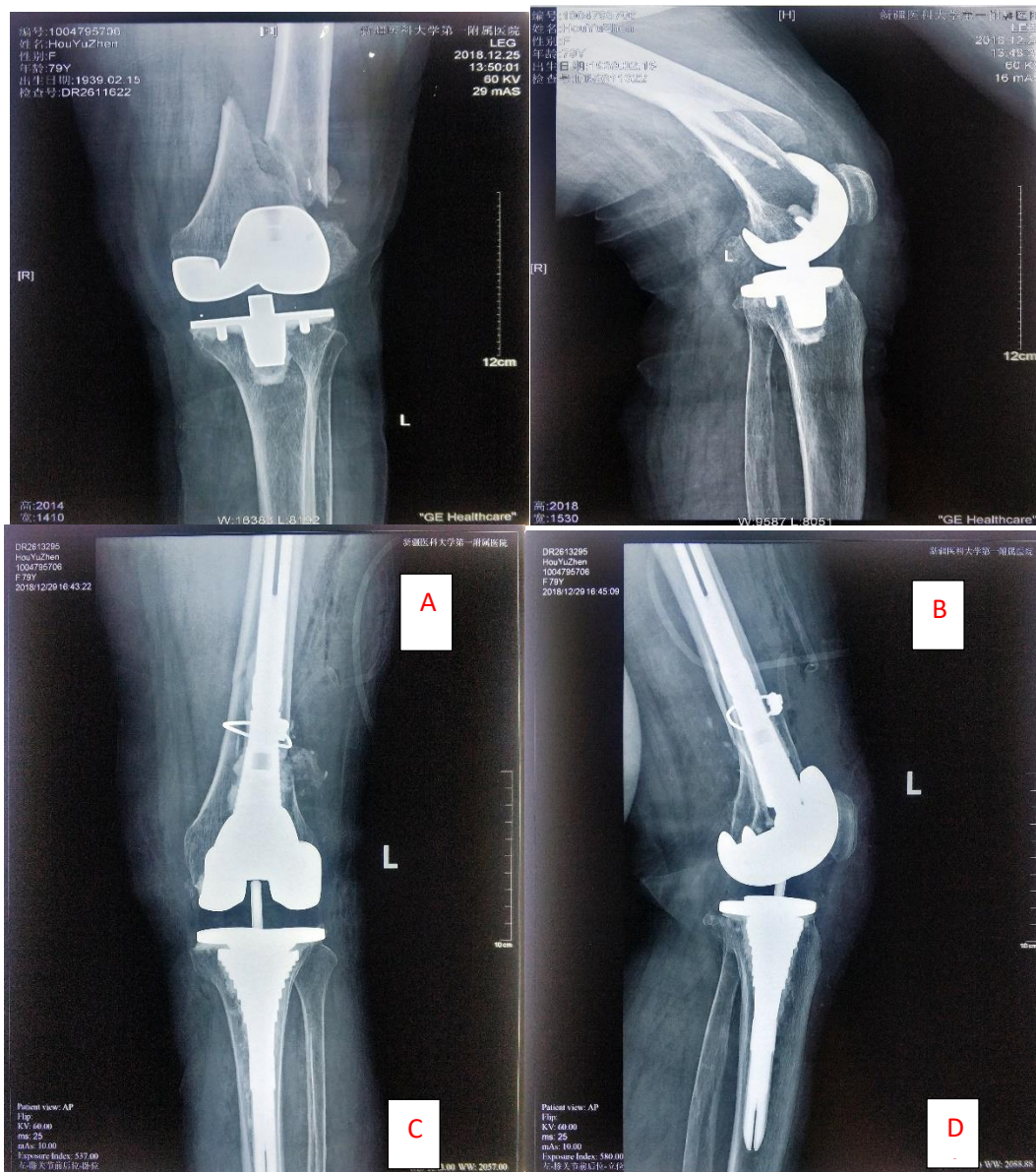
As the number of individuals taking primary or revision TKA is increasing, the relevant complications are also at increase. The goals of revision TKA include firm and stable fixation of the new implants, restoration of soft-tissue constancy, and fracture reconstruction of the bone. All tactics for dealing with bone loss involve compromises. For minor defects augmentation with or without Cement can be useful. There are

multiple reconstruction methods which are used to reconstruct the small and moderate bone defects but no best method is defined yet to overcome the osseous deficiencies<sup>10</sup>. For fixation of bone defects selection of method is highly dependent on the preference of surgeon and inversely dependent on the size and shape of bone and also on the location of bone defect<sup>11</sup>. Smaller defects like AORI Type 1 with approximately 5 mm or less can be managed with cement, localized cancellous or rarely structural bone grafts. Occasionally metal augments are used if the defect is 5 mm to 15 mm. In AORI type 2 as the defect increases in size the treatment options includes the cement, metal augments like sleeve or cone, and structural allograft are used (fig 1). The AORI Type 3 with larger defect can be treated with metal augmentation by porous cones or metaphyseal sleeves, graft impaction, structural allograft, and sometimes condylar-replacing prosthesis. Usually metaphyseal sleeves are an option for reconstruction of moderate to large bone defects, mainly the central ones (fig 2). While, the Porous cones can provide fixation and even considered as an effective tool for providing the support to femoral prosthesis. When significant bone loss is present, surgeons used augments to eradicate this threat and improve the implantation stability and fixation.





**Figure-1:** 45years/Male .The image A and B show the pre-operative periprosthetic fracture TKA, and Figure C and D show the revision TKA along with bone to reconstruct the bone loss.



**Figure-2:** 97yrs /Female,(a,b) shows post periprosthetic fracture , (c,d) revision TKA

The metaphyseal sleeve selection is limited by the small number of sleeve sizes available. Large defects may need more than a sleeve. Though, in many cases, it has been shown to be effective for achieving stable fixation. Jones et al. reported on use of metaphyseal sleeves in revision TKA, had good stability results in 30 patients with no mechanical failure after with mean follow up of 4.1 years<sup>12</sup>. In another study, reported on the use of tibial metaphyseal sleeves for severe metaphyseal bone loss in 34 knees with minimum two-year follow-up, all metaphyseal sleeves showed stable osseointegration<sup>13</sup>. Alexander et al. used metaphyseal sleeves for large tibial bone defects in 30 revision TKAs with a minimum two-year follow-up. At last follow-up the radiographs showed signs of ingrowth bone into the sleeves, and no evidence of components loosening<sup>14</sup>. No complications were found regarding the sleeves. Many other authors have shown similar successful results at short term follow-up<sup>14, 19</sup>. In the metaphyseal area the bone quality is better for fixation as compared to epiphyseal surface that is poor and unresponsive. While filling up bone defects the metaphyseal sleeves and cones allow fixation loading the metaphysis area and lessens the stress shielding and provides better rotational stability compared to a diaphyseal fixation alone. Usually metaphyseal metal devices are used to eradicate the type 3 bone defect but many authors used these devices for type 1 and type 2 defects. In our studies some of our patients had type 1 and type 2 bone defects. Different researchers tested sleeves on type 2 and type 3 bone losses. In the study of Chalmers et al. 33% patients were suffered from type 2 and type 3 bone deficiency and observed positive response of metaphyseal sleeves in his high risk patients<sup>13</sup>. Same in our studies most of the patients were identified from AORI type 2 and type 3 bone deficiency. Metaphyseal sleeves gains stability and fixation with either cemented or cementless. The less reliable use of this zone is the major reason behind the strategy. Different researchers argued that the restoration of optimal joint line and stability in fixation can be achieved through the zonal fixations. Zone 2 (metaphysis) and zone 3 (diaphysis) provide major role in implant stability<sup>14</sup>. For the fixation of zone 3 different researchers observed the validity and reliability of stems. They claimed that both cemented and cementless have some advantages and disadvantages after the implantations. The cemented stems effects in resorption and stress shielding at metaphysis, due to this patient suffers from stem pain<sup>15</sup>. Due to these problem 1% patients suffers from pain. To eradicate this issue different researchers examined the osseointegration in uncemented sleeves during first 3 months and analyzed that decrease in pains related to stem had direct relationship with the reduction in stem size

and percentage in canal filling process. In other study, the researchers also argued that fixation in zone 2 have less direct effect on zone 3 fixation<sup>14-16</sup>. When host bone combining with a cones it provide more stability and support to knee. In the study of Bobyn et al., he demonstrated that 70-80% porous ingrowth can be observed in 52 weeks<sup>17</sup>. In another study conducted by Findley et al demonstrated that the nature of porous increased the osteoblast, and even osseous ingrowth. In his study the most of the patients belong to type 3 bone defect<sup>18</sup>. The results of different studies were in favoring of femoral cones same as in our study. In our studies we observed that cemented and cementless stems are also another -alternative for fixation but sleeves provide more fixations without causing any stress on shielding. The results of revisions on aseptic loosening are quite similar with the study of Graichen et al are quite similar to our studies in which he observed 7% of aseptic loosening on 98% survivorship<sup>19</sup>.

In our study we observed the significant improvement in Knee society score with mean 87, range of motion at 120° degree with the significant functional score of 65. These arrangements of scores agreed with the previous study conducted by Lachiewicz et al in which he found the significant improvement of knee society score with the mean range of 3 years at 97% confidence interval<sup>28</sup>. These outcomes of our research also agreed with the published study of Schmitz in which he analyzed the improvement of knee society score among 18 patients and found 37 months as best in Kaplan-Meier survivorship analysis<sup>29</sup>. In our studies we examined the implant survivorship in different time intervals and our results demonstrates that 35 months are best and suitable for reducing risks among patients. We also found in our studies that the unrevised cones were better efficient than the other one at the time of latest follow up. These observations were more similar to the previous studies. Due to major issue of aseptic loosening among patients we found that 4% of cones provide splendid survivorship for TKA of Type 3 bone defect. These results are nearer to the study of Villanueva- Martinz et al in which he observed that 3% of cones established more significant effect on type 3 bone defect<sup>30</sup>.

#### CONCLUSION:

Knee revision for a periprosthetic fracture is a challenging and one of the complex operation which requires skillful surgeon and requires proper detailed comprehensive preoperative planning. Using of metaphyseal sleeves and cones represent a sustainable and feasible option in both septic and aseptic revision total knee arthroplasty with type AORI IIB and III bone deficiencies. Bone defects are well managed by these two devices with similar

clinical and radiological result and survival rate. They give more stability and control of rotation alignment of the components near the joint. Intraoperatively primary stability is achieved, either axial and or rotational with press-fit technique, and the bone ingrowth and osseointegration ensures the secondary stability. We strongly recommend further long term studies in revision total knee arthroplasty to better illuminate the clinical and radiological outcomes of this promising technique.

#### REFERENCES:

1. Kurtz S, Ong K, Lau E et al. Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. *J Bone Jt Surg Am.* 2007; 89(4):780
2. Morgan-Jones R, Oussedik S, Graichen H, Haddad F. Zonal fixation in revision total knee arthroplasty. *Bone Jt J.* 2015;97-B:147–149
3. Ponzio DY, Austin MS. Metaphyseal bone loss in revision knee arthroplasty. *Curr Rev Musculoskelet Med.* 2015; 8(4):361–367 -
4. Engh GA, Parks NL. *The management of bone defects in revision total knee arthroplasty. Inst Course Lect.* 1997; 46:227–236
5. Mancuso F, Beltrame A, Colombo E et al. Management of metaphyseal bone loss in revision knee arthroplasty. *Acta Biomed.* 2017; 88(2-S):98–111
6. Sheth NP, Bonadio MB, Demange MK. Bone loss in revision total knee arthroplasty: evaluation and management. *J Am Acad Orthop Surg.* 2017; 25(5):348–357
7. Lachiewicz PF, Bolognesi MP, Henderson RA, Soileau ES, Vail TP. Can tantalum cones provide fixation in complex revision knee arthroplasty? *Clin Orthop Relat Res.* 2012; 470(1):199–204
8. Pour AE, Parvizi J, Slenker N, Purtill JJ, Sharkey PF. Rotating hinged total knee replacement: use with caution. *J Bone Jt Surg Am.* 2007; 89(8):1735–1741
9. Kostuj T, Streit R, Baums MH, Schaper K, Meurer A. Midterm outcome after mega-prosthesis implanted in patients with bony defects in cases of revision compared to patients with malignant tumors. *J Arthroplasty.* 2015; 30(9):1592–1596
10. Divano S, Cavagnaro L, Zanirato A, Basso M, Felli L, Formica M. Porous metal cones: gold standard for massive bone loss in complex revision knee arthroplasty? A systematic review of current literature. *Arch Orthop Trauma Surg.* 2018; 138(6):851–863
11. Bonanzinga T, Gehrke T, Zahar A, Zaffagnini S, Marcacci M, Haasper C. Are trabecular metal cones a valid option to treat metaphyseal bone defects in complex primary and revision knee arthroplasty? *Joints.* 2017; 6(1):58–64
12. Jones RE, Barrack RL, Skedros J. Modular, mobile-bearing hinge total knee arthroplasty. *Clin Orthop Relat Res* 2001;306-14
13. Barnett SL, Mayer RR, Gondusky JS, Choi L, Patel JJ, Gorab RS. Use of stepped porous titanium metaphyseal sleeves for tibial defects in revision total knee arthroplasty: short term results. *J Arthroplasty* 2014;29:1219–24.
14. Alexander GE, Bernasek TL, Crank RL, Haidukewych GJ. Cementless metaphyseal sleeves used for large tibial defects in revision total knee arthroplasty. *J Arthroplasty* 2013;28:604–7
15. Boureau F, Putman S, Arnould A, Dereudre G, Migaud H, Pasquier G. Tantalum cones and bone defects in revision total knee arthroplasty. *Orthop Traumatol Surg Res.* 2015;101(2):251–255
16. Brown NM, Bell JA, Jung EK, Sporer SM, Paprosky WG, Levine BR. The use of trabecular metal cones in complex primary and revision total knee arthroplasty. *J Arthroplasty.* 2015;30(9 Suppl):90–93
17. Bobyn JD, Stackpool GJ, Hacking SA, Tanzer M, Krygier JJ. Characteristics of bone ingrowth and interfacial mechanics of a new porous tantalum biomaterial. *J Bone Joint Surg Br.* 1999 Sep;81(5):907-14.
18. Findlay DM, Welldon K, Atkins GJ, Howie DW, Zannettino AC, Bobyn D. The proliferation and phenotypic expression of human osteoblasts on tantalum metal. *Biomaterials.* 2004;25(12):2215-27.
19. Graichen H, Scior W, Strauch M. Direct, cementless, metaphyseal fixation in knee revision arthroplasty with sleeves-short-term results. *J Arthroplasty.* 2015;30(12):2256-9. Epub 2015 Jun 20.
20. Göttsche D, Lind T, Christiansen T, Schrøder HM. Cementless metaphyseal sleeves without stem in revision total knee arthroplasty. *Arch Orthop Trauma Surg.* 2016; 136(12):1761–1766
21. Huang R, Barrazaeta G, Ong A, Orozco F, Jafari M, Coyle C, Austin M. Revision total knee arthroplasty using metaphyseal sleeves at short-term follow-up. *Orthopedics.* 2014; 37(9):e804–e809
22. Martin-Hernandez C, Floria-Arnal LJ, Muniesa-Herrero MP, Espallargas-Doñate T, Blanco-Llorca JA, Guillen-Soriano M, Ranera-Garcia M. Mid-term results for metaphyseal sleeves in revision knee surgery. *Knee Surg Sports Traumatol Arthrosc.* 2017;25(12):3779–3785
23. Meneghini RM, Lewallen DG, Hanssen AD. Use of porous tantalum metaphyseal -

- cones for severe tibial bone loss during revision total knee replacement. *J Bone Joint Surg Am.* 2008;90(1):78-84.
2. Haas SB, Insall JN, Montgomery W 3rd, Windsor RE. Revision total knee arthroplasty with use of modular components with stems inserted without cement. *J Bone Joint Surg Am.* 1995;77(11):1700-7.
24. Long WJ, Scuderi GR. Porous tantalum cones for large metaphyseal tibial defects in revision total knee arthroplasty: a minimum 2-year follow-up. *J Arthroplasty.* 2009;24:1086-1092
25. Chun CH, Kim JW, Kim SH, Kim BG, Chun KC, Kim KM. Clinical and radiological results of femoral head structural allograft for severe bone defects in revision TKA: a minimum 8 year follow-up. *Knee.* 2014;21:420-423.
26. Engh GA, Ammeen DJ. Bone loss with revision total knee arthroplasty: defect classification and alternatives for reconstruction. *Instr Course Lect.* 1999;48:167-75.
27. Bauman RD, Lewallen DG, Hanssen AD. Limitations of structural allograft in revision total knee arthroplasty. *Clin Orthop Relat Res.* 2009;467:818-824.
28. Lachiewicz PF, Bolognesi MP, Henderson RA, Soileau ES, Vail TP. Tantalum cones provide fixation in complex revision knee arthroplasty? *Clin Orthop Relat Res.* 2012;470(1):199-204.
29. Schmitz H C, Klauser W, Citak M, Al-Khateeb H, Gehrke T, Kendoff D. Three-year follow up utilizing tantalum cones in revision total knee arthroplasty. *J Arthroplasty.* 2013 Oct;28(9):1556-60. Epub 2013 May 8.
30. Villanueva-Martínez M, De la Torre-Escudero B, Rojo-Manaute JM, Ríos-Luna A, Chana-Rodríguez F. Tantalum cones in revision total knee arthroplasty. A promising short-term result with 29 cones in 21 patients. *J Arthroplasty.* 2013 Jun;28(6):988-93. Epub 2013 Feb 13.