Modified Buried Vertical Mattress Suture Lowers Risk Of SSI, Reduces Use Of Antibiotics, And Improves Clinical Outcomes After TKA: A Retrospective Study Up To 48-month Follow-up

Meng Feng[1,2]*, Songyu Gong[1], Yiling Guo[1], Sheng Dai[1], Haiquan Yu[3], Genwen Mao[1], Jianlong Ni[1], Xiaoqian Dang[1], Chang Hun Lee[2], Zhibin Shi[1]
1. Department of Orthopedics, The Second Affiliated Hospital of Xi′an Jiaotong University, Xi′an 710006, People′s Republic of China;
2. Regenerative Engineering Laboratory, Columbia University Irving Medical Center, New York 10032, USA;
3. Department of Orthopedics, The First Affiliated Hospital of Hebei Medical University, Shijiazhuang 050023, People′s Republic of China
*Email address: meng_feng@xjtu.edu.cn

Disclosures: 3B: Zhibin Shi, MD, is a paid consultant from LINK, Germany; Depuy MITIK, USA; Rejoin, China. Others: None.

INTRODUCTION: **Peri-prosthetic infection (**PJI) after total knee arthroplasty (TKA) causes severe joint pain and opioid-related overuse in immune-compromised patients including rheumatoid arthritis, SLE, Behçet's disease and chronic kidney disease treated with glucocorticoid. PJI limits the full range of motion and contributes to the inappropriate use of antibiotics. PJI drives mental anxiety and higher morbidity and mortality. It also prolongs hospitalization stays and increases the financial burden for China's underserved families and communities. **Surgical site infection** (SSI) is a well-established risk factor for subsequent PJI. SSI often forms the sinus tract communicating with prosthesis within one year leading to disastrous results in elective TKA. Previous clinical trials reported that stapling and simple intermittent suturing (control) might carry a higher risk of SSI. However, there are no preventive, effective, and inexpensive techniques to lower the risk of SSI and PJI, reduce the usage of antibiotics, shorten hospitalization stays, and improve clinical outcomes. **Modified buried vertical mattress suture** (MBVMS) is a wedge-shaped incision and "heart-shaped" suture technique (Figure 1). This technique provides optimum tension-reduction effectiveness, decreases the healing time of incision, and induces less hypertrophic scar formation. We **hypothesize** that MBVMS could decrease the rate of SSI and PJI, reduce medical costs and improve the life quality of patients after TKA.

METHODS: This study was approved by IRB at Xi'an Jiaotong University. Clinical records were collected from 386 patients (242 female, 144 male) from August 2018 to August 2022, with a minimum of 12 months of follow-up. Patients with end-stage OA or rheumatoid arthritis underwent TKA by the senior surgeons with a medial parapatellar approach. Cefazolin/ cefotetan (2g, Q12h)/ clindamycin (0.6g, q12h) were administrated before the operation and extended up to 3 days for antimicrobial prophylaxis purposes. Criteria for diagnosis of PJI include sinus tract communicating with the prosthesis, identification of microorganism isolated from at least 2 cultures, elevated synovial fluid leukocyte count, neutrophil percentage, serum ESR (>30mm/h) and c-reactive protein according to the 2013 Infectious Diseases Society of America and 2011 Musculoskeletal Infection Society guidelines. We used Quill barbed suture which could eliminate the need to tie knots to secure closure of the knee joint capsule and deep fascia (Figure 1). An antimicrobial suture (#4-0 Ethicon) was then used to close the skin which also provided mechanical support for wound healing. The surgical incision complication rates were recorded. The aesthetic appearance of each scar was evaluated by the Patient and Observer Scar Assessment Scale (POSAS), the Vancouver Scar Scale (VSS), the Hollander Wound Evaluation Scale (HWES), and the cosmetic Visual Analog Scale (VAS) after 3, 6, 12 months. Confirmed PJI cases after TKA were either treated with debridement, antibiotics, irrigation and implant retention (DAIR), or 2-stage arthroplasty exchange/ joint fusion. Vancomycin (1g, Q12h) / linezolid (0.6g, Q12h) combined with rifampin (0.45mg, QD) were selected to eradicate biofilms on prosthesis surfaces for 2 to 6 weeks, followed by oral moxifloxacin (500mg) to a complete 6 months for TKA revision. Student's *t*-test for two group comparisons for differences was utilized.

RESULTS: To determine the effects of MBVMS on incision healing and medical costs, we collected medical records and analyzed the data. MBVMS shortens stitch in-out time and skin suture knot time compared to the control (average of 25 min versus 55 min, respectively). Gross examination showed that MBVMS surgical incision integrated well within 7 days and had a normal-like appearance, while traditional intermittent sutures took more than 14 days to integrate well (Figure 2). Compared to the simple intermittent suture control, MBVMS only costs half of the amount (average cost of 92,655 versus 48, 982.06 RMB, respectively). Apart from the incision healing time, the scar condition was further quantified via VSS and POSAS assessment. Our results showed that VSS and POSAS were greater after MBVMS intervention relative to control at 3 months, 6 months, and 12 months. Moreover, MBVMS had less scare width and area compared to the control (Figure 3). To further assess the effects of MBVMS on cosmetic outcomes, HWES and VAS were assessed. It showed that MBVMS had higher HWES (5 to 6), VAS and patient-reported satisfaction rate (99%) compared to the control. To further examine the effects of MBVMS on the safety and prevention of SSI, we further screened the record databank and obtained hospital readmission and TKA revision times with a minimum 12-month follow-up. Intriguingly, SSI-induced hospital readmission and PJI-associated TKA revision (n=21, incidence was 5.4%) were only seen in the control group (Figure 4). Unavoidable hospital readmission number was doubled in the control (average 3 times) and up to 6 times. Hospitalization days were more than 4 weeks which increased healthcare costs (average 174, 836 RMB). Secondly, many different microorganisms have been implicated in SSI and prosthesis infection. The most common bacteria were identified as *Staphylococcus aureus* and *enterococci* (*Enterococcus faecium, Escherichia coli,* and *Klebsiella aerogenes*). These prevalent pathogens are responsible for polymicrobial infection in early-onset SSI and PJI according to the culture in the nosocomial setting. Lastly, the application of MBVMS significantly decreased the use rate of vancomycin and linezolid from 21.13% to less than 1%, and shortened the administration duration compared to control, especially in patients with rheumatoid arthritis.

DISCUSSION: Delayed healing of surgical incision may increase the risk of SSI, where bacteria may penetrate the deep fascia and knee capsule causing PJI. SSI and PJI are considered issues of health disparities, including females with higher incidence of rheumatoid arthritis and SLE, as well as economic factors. SSI and PJI result in chronic suffering for patients who received TKA. To cure SSI and PJI, current therapies often lead to the overuse of antibiotics for more than 6 weeks, which may contribute to the antibiotic-resistant gene formation in bacteria. The clinical use of vancomycin usually induces hypersensitivity in patients with TKA revision at the rate of 20%. Moreover, PJI increases the cost, runs a high risk of readmission rate, and contributes to longer hospitalization. Here, we introduced an effective and inexpensive surgical technique, MBVMS, yielding a less hypertrophic scar and faster healing of the incision. The reason could be that MBVMS with helical barbed suture evenly distributes tension, increasing efficiency, security and speedy healing process of surgical wounds. Importantly, the application of MBVMS could lower medical costs, prevent infectious problems, and eliminate health disparities in Northwestern China. Our clinical study further revealed MBVMS could effectively decrease the rates of antibiotic overuse including vancomycin and linezolid, and reduce risk factors of PJI and TKA revision. Lastly, our study set the foundation for future direction, to register a prospective trial and provide optimal translational treatment options.

CLINICAL RELEVANCE: The MBVMS procedure could shorten hospitalization time, reduce the cost and usage rate of antibiotics, lower the risk of SSI- and PJI-related hospital readmission numbers, as well as improve clinical outcomes after TKA.

Figure 1 Schematic graph deciphers the intermittent suture and MBVMS procedure.

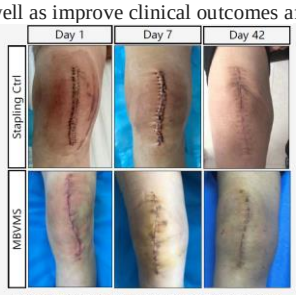

Figure 2 The presentative images show that surgical incision integrates faster in the MBVMS compared to stapling control.

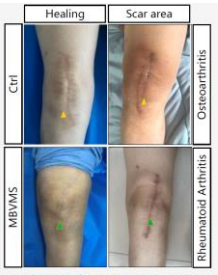

Figure 3 Surgical incision healing and aesthetic scar assessment post TKA over 12 months.

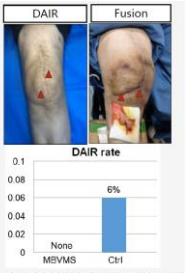

Figure 4 Rate of SSI and PJI after TKA which incision was closed by intermittent suture.