Zero surgical site infection in primary knee arthroplasty with multidisciplinary intervention: is it possible?

Zehra Çağla Karakoç¹, Uğur Haklar²
¹Department of Infectious Diseases and Clinical Microbiology, İstinye University Medical Faculty, Istanbul, Turkey; ²Department of Orthopedics and Traumatology, Istanbul, Bahçeşehir University Medical Faculty, Turkey

SUMMARY
Surgical site infections (SSI) are among the most important complications in knee arthroplasty. In this article we aim to retrospectively evaluate effects of preoperative multidisciplinary assessment and treatment of focal infections in primary knee arthroplasty patients operated by a single surgeon in a single center. A total of 93 patients undergoing 120 primary knee arthroplasty operations were included in the study. In the preoperative assessment all patients were consulted by infectious diseases, otorhinolaryngology (ENT) and dentistry departments, and female patients additionally by gynecology departments to evaluate and treat possible focal infections. Decolonization protocols were implemented for the bacterial growths detected in nasal and urine cultures. Patients received one of four surgical interventions, namely unilateral total knee arthroplasty (TKA), unilateral robotic-assisted unicompartmental knee arthroplasty (RUKA), bilateral RUKA or unilateral TKA and unilateral RUKA. No patients received bilateral TKA in a single session. Out of 93 patients 70 (75.3%) were female, mean age was 67.7±9.9 years, and American Society of Anesthesiologists (ASA) scores were <3 for 93.5% of the study group. Fifty-two (55.9%) of the patients received RUKA. Mean value for the duration of operations was 150.7±67 minutes, for hospitalization it was 5.9±2.8 days, and postoperative follow-up was 25.7±8.8 months. None of the patients developed SSI in the follow-up period. Many factors are associated with SSI after knee arthroplasty. Total absence of SSI in our study group may be attributable to meticulous patient selection, multidisciplinary preoperative assessment, and the performance of RUKA by a single surgeon in a single center. Keywords: intervention, primary knee arthroplasty, surgical site infection.

INTRODUCTION

Number of patients receiving knee arthroplasty is consistently increasing with the ageing world population. It is estimated that 3.48 million patients will undergo knee arthroplasty in 2030 [1]. It is reported that number of knee arthroplasties performed in Turkey also showed an increasing trend over the years to reach 70991 operations in 2014 [2].

One of the most important complications of knee arthroplasty is the surgical site infection (SSI) which is associated with increases in both morbidity and economic burden [3]. SSI diagnosis may not always be straightforward in clinical practice. It may not be easy to identify the source of postoperative fever and in addition to intraoperative culture samples, nuclear and histologic tests may also be useful in diagnosing prosthetic infections [4, 5]. Current infection rates in knee arthroplasty are below 2% [6, 7]. To prevent and lower the rates of SSIs, many precautions are taken before, during and after surgery [8, 9]. Evaluating possible infection sites during preoperative assessment is a key point in preventive medicine.
Staphylococcus aureus is one of the major microorganisms responsible for SSI and the most common pathogen causing knee arthroplasty site infections [10]. A number of studies investigated the effect of preoperative S. aureus decolonization on SSI and despite contradictory results, most reports indicated a decrease in SSI rates [11, 12]. Since its introduction in 2009, practice of robotic-assisted unicompartmental knee arthroplasty (RUKA) has been constantly improved and performed worldwide [13,14]. Most important advantages of RUKA are being less invasive than conventional manual methods, ideal placement of the prosthesis and early recovery [15]. In this article we aim to retrospectively evaluate the SSI rates in primary knee arthroplasty patients operated by a single surgeon in a single center after multidisciplinary preoperative assessment and treatment of possible risk factors for infection.

 MATERIALS AND METHODS

A total of 93 consecutive patients who underwent a total of 120 primary knee arthroplasties at a single-center by a single surgeon (U.H.) between 07.01.2013 and 31.12.2015 were enrolled in the study. Arthroplasty was indicated in patients with at least one of the following problems after all medical treatments had been tried: not being able to walk continuously for 100 meters without support, daily requirement of pain killers or waking up at night because of the pain, displaying knee deformities which may cause deformity in nearby joints and requiring people help for daily activities because of the osteoarthritis. Prosthesis revision cases were excluded. Operations of two patients were postponed and they were excluded from the study due to malignancies detected in the preoperative assessment (one case with unexplained increase in erythrocyte sedimentation rate diagnosed with endometrial cancer and the other with a suspicious opacity in the chest X-ray diagnosed with lung cancer). The remaining 93 patients were included in the study and these patients received a total of 120 operations (patients receiving bilateral total knee arthroplasty or RUKA in different sessions were recorded as two operations). Ethical approval was obtained from the Medical Ethics Committee of Bahçeşehir University Faculty of Medicine with the number 020-25.

Pre-operative intervention
All patients were consulted by infectious diseases, dentistry and otorhinolaryngology (ENT) specialists and female patients also by gynecologists for possible focal infection sites. Detected infections which may disseminate hematologically such as gingivitis, tooth abscess, sinusitis, vaginitis, vulvitis and cervicitis were treated prior to surgery. Preoperative laboratory tests included complete blood count, C-Reactive Protein (CRP), erythrocyte sedimentation rate (ESR), liver and kidney function tests, viral serology, urinalysis and urine microscopic examination in addition to microbiological cultures of nose and urine (Table 1). Chest X-rays were taken. Patients with interdigital or inguinal fungal infections were treated by a dermatologist.

Patients who had S. aureus colonization in the nose cultures were treated by the same infectious diseases specialist (Z.Ç.K.) for 7 days with the proper oral antibiotic and given a brochure describing the whole-body wash with chlorhexidine (Table 2). Nose cultures were repeated 48 hours after the completion of antibiotics to document decolonization. Patients with bacteriuria ≥100,000 CFU/mL were treated with antibiotics according to the antibiogram results and were operated after confirmation of decolonization with a control urine culture.

Peri-operative and intra-operative intervention
Patients received one of the four knee arthroplasty procedures in a single session, which were unilateral total knee arthroplasty (TKA)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leukocyte (3980-10004)/mm³</td>
<td>7242±1841.8</td>
</tr>
<tr>
<td>Hemoglobin (11.7-17.2) mg/dL</td>
<td>13±1.3</td>
</tr>
<tr>
<td>Hematocrite (34.1-44.9)</td>
<td>39.9±3.8</td>
</tr>
<tr>
<td>Thrombocytes (182000-369000)/mm³</td>
<td>266989.2±78534.7</td>
</tr>
<tr>
<td>CRP (0-5) mg/L, Median (min-max)</td>
<td>8 (1.2-82)</td>
</tr>
<tr>
<td>ESR (0-20) mm/hour</td>
<td>25.5±17.2</td>
</tr>
<tr>
<td>AST (0-32) U/L</td>
<td>17.5±7.1</td>
</tr>
<tr>
<td>ALT (0-33) U/L</td>
<td>19.6±13.9</td>
</tr>
<tr>
<td>BUN</td>
<td>17±6.4</td>
</tr>
<tr>
<td>Creatinine (0.5-0.9) mg/dL</td>
<td>0.7±0.1</td>
</tr>
</tbody>
</table>
Surgical site infection in primary knee arthroplasty

(group 1), unilateral RUKA (group 2), bilateral RUKA (group 3), and unilateral TKA and unilateral RUKA (group 4). Bilateral TKA were not performed in the same session. All subjects were recommended to have a shower with water and soap the night before the operation. The area between the inguinal region and the ankle at the planned operation side was shaved with an electric razor on the day of the surgery. A solution of 10% povidone iodine was used for preoperative skin preparation - sterile drying - painting with 10% povidone iodine. Cefozolin 1-2 g IV was administered for surgical prophylaxis 15 minutes before inflating the tourniquet and stopped in 24 hours. Stryker helmet and single use operation cloth and scrubs were used. Intraoperative normothermia was maintained.

Epidural catheterization and general anesthesia were applied to all the patients. Epidural catheter was removed within 48-72 hours from the patients whose postoperative pain was alleviated. Urinary catheterization was applied to all patients and it was also removed within 24 hours with the drains. Surgeon performed the routine gloves change before the use of cement. Tranexamic acid was administered to minimize perioperative blood loss. Ranawat cocktail [0.5% (200-400 mg) 24 cc of bupivacaine, 8 mg of morphine sulfate 0.8 cc, (1: 1000) 300 μg epinephrine 0.3 cc, 40 mg of methylprednisolone acetate 1 cc, 22 cc of 0.9% sodium chloride] was injected into the medial, lateral and anterior sub synovial tissue for analgesic and anti-inflammatory effects and bleeding control before the posterior capsule prosthesis was placed. Surgical procedures were performed by the same surgeon and the same surgical team in operation rooms provided with laminar air flow. During surgery, the operation room doors were kept closed to minimize entry and exits.

**Surgical technique**

In total knee prosthesis, anterior longitudinal incision was used for entry. Without decoupling of the subcutaneous tissue entry to the joint was made with medial parapatellar capsulotomy through middle of the quadriceps tendon. The GENESIS™II Total Knee System (Smith&Nephew USA) implant with cement was installed with the standard technique. Intramedullary guides were placed to the femur and tibia. Pulse lavage (pressured wash) was performed after osteotomies. Components were fixated with third generation bone cement without antibiotics. Joints synovia was sutured with Ethicon-Monocryl 3 - 0 before the closing of the joint capsule. Joint capsule was sutured with interrupted Polysorb Coviden - 0. Hemovac drains were placed both in the joint and subcutaneous tissue. Subcutaneous tissue was continuously sutured with polysorb Coviden 2 - 0. Skin was sutured continuously with Ethicon-Monocryl 2 - 0.

In RUKA, set up was done according to the Stryker RIO MAKO surgical method. Depending on the location of the arthrosis, an anterolateral or anteromedial parapatellar longitudinal incision was performed and arrays were inserted into the femur and tibia. Robotic navigation system determined the spatial coordinates of the femur and tibia. After the topographic details of the femur and tibia were analyzed by the system, osteophytes were removed. Ligament balance was achieved with robotic assistance. After the final positions of the prosthesis were determined osteotomies were performed. Joint functions were controlled with kinematic analysis, components with cement were inserted to femur and tibia. Trial insertions were placed. Following the reconfirmation with kinematic analysis, permanent polyethylene insertions were placed and with placements of drains, insertion sites were closed.

<table>
<thead>
<tr>
<th>Table 2 - Decolonization regimen.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultures</td>
</tr>
<tr>
<td>Treatment</td>
</tr>
</tbody>
</table>

(Culture MSSA (+) Culture MRSA (-) Culture Urine culture Treatment Cephalexin 1g tb. X 4/day for 7 days + 4% CHG body wash (on the day 1 and 6) Trimethoprim-sulfamethoxazole cps (800/160 mg) X 2 + Rifampicin 600 mg./day for 7 days + 4% CHG body wash (on the day 1 and 6) Decolonization with proper antibiotics in patients with ≥100.000 CFU/mL bacteriuria
Postoperative intervention
Bleeding control was achieved by hemovac drains and good hemostasis during surgery. Twelve hours after epidural catheter insertion, 10 – 15 mg/day oral rivaroxaban was started for venous thromboembolism prophylaxis and continued for four weeks. Mobilization with a walker started one or two days after the removal of hemovac drains. Povidone iodine was not used for dressings. Dressings were removed at the 5th day after drain removal, if no bleeding or leakage was observed 24 hours after drain removal. Patients’ follow ups were performed by the same orthopedic surgeon at the 2nd, 4th and 6th weeks and 3rd and 6th months and the 1st year. Physical rehabilitation continued for 30 to 45 days postoperatively. Presence of infection at the surgical site was checked and recorded during the 12 months of follow up.

Statistical analysis
Age, gender, body mass index (BMI), comorbidities, habits, laboratory test results, microbiological findings, chest X-rays, ENT, dentistry, gynecological and dermatological examinations for possible focal infection sites, American Society of Anesthesiologists (ASA) Score, type and duration of operation, surgical prophylaxis type and duration, blood transfusions, drain and catheterization durations, postoperative complications and hospitalization days were recorded and analyzed by SPSS (Statistical Package for Social Sciences) for Windows 22.0 software.

RESULTS
A total of 120 operations were performed on 93 patients. Mean age of the patients was 67.7±9.9 (range: 44-90) years and 70 (75.3%) patients were female. Of the study group, 34.1% were in group 1, 20.8% were in group 2, 36.6% were in group 3 and 8.3% were in group 4. ASA scores of 5.3% of the study group were ≥3. A total of 58 (62.3%) patients had at least one comorbidity. Most common comorbidities in the study group were cardio-cerebrovascular system conditions (hypertension, heart valve diseases, abnormal rhythms, ischemic hearth conditions and stroke) (33.3%), diabetes mellitus (21.5%) and rheumatologic disorders (rheumatoid arthritis, psoriasis, gout) (7.5%). Smokers were 8.6% of the study group and there were no alcoholics. Pre-operative features of the patients can be seen in table 3. Forty-two patients received dermatological treatments [3 patients for psoriasis, 1 patient for vitiligo and 38 patients for fungal infections (tinea pedis, tinea inguinalis, onychomycosis)] and 27 patients received dental treatments (17 tooth extractions, 5 fillings and 5 periodontological treatments).

Nose and urine cultures, performed to evaluate possible focal infection sites, did not reveal any colonization in 82.8% of the patients. Urine cultures of 4 patients revealed *Escherichia coli* colonization (≥100,000 CFU/mL) and 10 patients had methicillin sensitive *Staphylococcus aureus* (MSSA) and 2 patients had methicillin resistant *Staphylococcus aureus* (MRSA) colonization in their nose cultures. These patients received antibiotics in accordance with the decolonization program. Patients received cefazolin for antibiotic prophylaxis except for the 2 cases with MRSA. Prophylactic antibiotics were stopped in 24 hours after the procedure in 96.7% of the cases. In 3 cases surgical prophylaxis was extended because of the developed urinary tract infection and open wound in the foot due to gout disease.

Endocrinology consultation was requested for 4 of the 20 diabetic patients due to high (>7%) HbA1c levels. Preoperative and postoperative blood sugar regulations were provided. Five patients received erythrocyte transfusion without

<table>
<thead>
<tr>
<th>Table 3 - Pre-operative features.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Characteristics</td>
</tr>
<tr>
<td>Age, mean years ± SD</td>
</tr>
<tr>
<td>Gender, female/male</td>
</tr>
<tr>
<td>BMI (kg/m²), mean ± SD</td>
</tr>
<tr>
<td>Smoke/Alcohol</td>
</tr>
<tr>
<td>Underlying diseases</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
</tr>
<tr>
<td>Cardio-cerebrovascular diseases</td>
</tr>
<tr>
<td>Rheumatologic diseases</td>
</tr>
<tr>
<td>ASA score ≥ 3</td>
</tr>
<tr>
<td>Hospitalization days, mean ± SD</td>
</tr>
<tr>
<td>Surgical procedure number /</td>
</tr>
<tr>
<td>Procedure time (min), mean ± SD</td>
</tr>
<tr>
<td>Group 1</td>
</tr>
<tr>
<td>Group 2</td>
</tr>
<tr>
<td>Group 3</td>
</tr>
<tr>
<td>Group 4</td>
</tr>
</tbody>
</table>
Surgical site infection in primary knee arthroplasty

Mean hospitalization time was 5.9 ± 2.8 days and mean operation duration was 150.7±67 minutes. Mean hospitalization and operation durations for each group are shown in Table 3. Mean follow up duration was 25.7 ± 8.8 months and zero patients developed SSI in that period. But in the short term (postoperative 3 months) 4 patients developed hematoma, 2 patients developed urinary tract infection and in the long term 2 patients developed peroneal nerve paralysis, 2 patients developed arthrofibrosis and all responded to treatment.

**DISCUSSION**

Among our study group which included a total of 93 retrospectively investigated and still prospectively followed up patients undergoing 120 primary knee arthroplasty procedures, no SSI cases were detected during a mean follow-up period of 25.7±8.8 months (range: 12-47 months). Despite the limited size of the study group, this is a remarkable achievement when compared to the previous SSIs reports [9, 16]. Among the prominent factors underlying these results include meticulous patient selection, multidisciplinary preoperative assessment of the patients to eliminate focal infection sites and the single surgeon – single procedure approach. Factors that increase the risk of SSIs in knee arthroplasty include ASA score, obesity, diabetes mellitus, rheumatoid arthritis, arthroplasty revision surgery, *S. aureus* colonization, inappropriate antibiotic prophylaxis, extended duration of operation, allogeneic blood transfusions, focal infections elsewhere in the body, malignancies, immunosuppression and comorbidities [17]. Recently Ascione et al. reported a study including 122 patients with prosthetic joint infection highlighting that patients with comorbidities report the highest rate of SSIs [18].

Exclusion of patients undergoing prosthetic revisions and those with malignancies led to decreased SSIs development. Revision arthroplasties are reported to have a greater SSIs risk associated with extended duration of operation, undetected infection sites and soft tissue disorders [19-21]. Malignancies have also been associated with SSIs [22]. Obesity and morbid obesity are also considered as risk factors for SSIs in many studies due to extended duration of operation, comorbidities and more frequent requirement for blood transfusions [23-26]. There were 62 obese and 4 morbidly obese patients in our study group who are not considered to have a negative effect on the outcome. Diabetes mellitus is associated with increased infection risk due to increased biofilm formation, leukocyte dysfunction and delayed wound healing [26, 27]. Although 21.5% of the patients were diabetic, blood glucose levels were well controlled in the study group, only 4 patients had a HbA1c level >7. Another risk factor for SSI is an ASA score of ≥3 [26,27]. Vast majority of our study group (93.5%) had an ASA score <3.

Avoiding blood transfusions by keeping the preoperative hemoglobin levels >12 g/dL and minimizing the blood loss during surgery are important in preventing SSIs in arthroplasty [28]. Preoperative hemoglobin levels, which were >12 g/dL in the vast majority (69.8%) of our study group, intraoperative tranexamic acid administration for bleeding control and the RUKA method applied in 55.9% of the operations were important factors in keeping the rate of postoperative blood transfusion at 5.3%. Robotic innovations are known to be used in knee orthopedics since 2004 [29]. RUKA method enables both ideal orientation and alignment of the prosthetic parts with preoperative computer assisted planning and more accurate osteotomies with the help of the robotic arms. This method is associated with lower blood loss, less tissue trauma, lower morbidity and earlier recovery compared to TKA [14,30,31]. Performing this less invasive method on more than half of the patients may also be a factor for the absence of SSIs in our study group.

In arthroplasty patients, SSIs may be associated with oral and dental infections [32, 33]. Although routine preoperative intraoral focal infection screening is controversial, assessment of oral hygiene with a questionnaire or dental examination is suggested with strong level of evidence in the latest consensus report [34]. Because oral hygiene is reported to be poor in up to 85% of the elderly population in our country, we preferred an examination by a dentist preoperatively and delayed the arthroplasty in case dental treatment was required [35, 36].

*S. aureus*, a common member of the human flora frequently colonizing the nose along with larynx, gastrointestinal tract and the axillary region, is a prominent agent in SSI. Because *S. aureus* is the
most common bacterium isolated from high risk orthopedics patients with SSI, a number of studies have investigated the effects of preoperative S. aureus decolonization with intranasal mupirocin and/or whole-body chlorhexidine bathing on SSI rates [11, 12, 37]. Although the results were not consistent, 2013 International Consensus Meeting on Surgical Site and Periprosthetic Infection report stated that decolonization was associated with lower SSI rates [34]. S. aureus colonization rate was 12.9% in our study group and these patients were decolonized according to a designated protocol which included an oral antibiotic due to the lack of an available topical mupirocin formulation in the local market that could be applied to the mucosa. In case of MRSA colonization, a protocol including rifampicin was preferred due to its high rate of eradication [37, 38]. Decolonization of asymptomatic bacteriuria before knee arthroplasty is controversial [39]. We preferred to decolonize four patients with asymptomatic bacteriuria considering a possible urinary tract infection as a risk factor for SSI.

In recent years, bundle protocols developed for knee arthroplasty has been reported to decrease SSI. The bundle protocol proposed by Bullock MW et al. containing preoperative, perioperative and postoperative measures, which was investigated on 890 primary TKA subject over 2 years, was reported to decrease SSIs by 92.3%, which was statistically significant [8]. After a protocol was implemented, SSIs rates were reported to decrease from 12.9% to 1.9% in an article by Gottschalk et al. [16]. We also eliminated the focal infections by a multidisciplinary approach and similarly used a single protocol for all patients who were operated and followed up by a single surgeon preoperatively and postoperatively. Our unsophisticated method, which led to highly successful outcomes, may be applied to other knee arthroplasty series.

The major limitations of the study were the limited sample size, the single site study and the lack of a control group to compare the effects of the decolonization regimen.

**CONCLUSION**

SSIs in knee arthroplasty are multifactorial. Therefore multidisciplinary approach is of high significance and value. Meticulous patient selection, preoperative multidisciplinary assessment, preoperative and postoperative care by a single surgeon and the application of RUKA method were among the factors leading to successful outcomes regarding SSIs but further research will be necessary in this field.

**ACKNOWLEDGEMENTS**

The authors would like to thank Binnur Şimşek, MD. for her thoughtful review of the manuscript.

**Conflict of interests**

The authors declare that there is no conflict of interest regarding the publication of this article.

**REFERENCES**


