



ORIGINAL ARTICLE



Peri-Prosthetic Infection in the Orthopedic Tumor Patient

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Abstract

Background: Infection complicates traditional joint reconstruction prostheses in up to 7% of cases, with even higher rates in oncologic cases.

Questions / Purposes: The authors ask if prosthetic infection in bone tumor patients is associated with any epidemiologic, treatment, or outcome variables that could influence management of these difficult conditions.

Patients and Methods: Authors retrospectively reviewed 329 consecutive bone tumor (malignant and benign) patients treated with hip or knee tumor resection and subsequent joint reconstruction, comparing infected and non-infected cases. Patients were followed for a mean of 34 months.

Results: Of lower extremity tumor reconstructions, 13.1% developed periprosthetic infection, with the knee significantly more involved than the hip (20.5% vs 6.1%). The most common organism cultured was *Staphylococcus aureus* (33%). The diagnosis of sarcoma was associated with a higher infection rate, and infections were associated with a two-fold increase in number of total surgeries. Adjuvant radiation alone and chemotherapy alone (but not in combination) was associated with statistically increased infection rates. Debridement with fixed implant retention achieved a 70% infection remission rate, as opposed to 62% with two-staged treatment, and 100% with amputation. The implants tended to survive longer than the patients.

Conclusions: Infection complicates lower extremity prosthetic joint reconstructions in tumor patients more frequently than in non-tumor arthroplasty cases, with eradication rates lower than that of non-tumor patients. Periprosthetic infection correlates with radiation and chemotherapy administration, as well as an overall increase in revision surgery. Single stage debridement procedures result in infection remission rates comparable to two-stage reconstructions.

Level of Evidence Level III, Retrospective comparative study.

Introduction

Periprosthetic joint infection remains a very common cause of failure of hip and knee arthroplasty [12]. The prevalence of infection in total knee arthroplasty ranges from 0.9% [13], to 2.01% [19], to 4.0% [1], while recent studies document the prevalence of infection in total hip arthroplasty at 1.1 – 2.2% [25, 26]. Another study notes a 1 – 7% infection prevalence in all primary joint arthroplasty

cases [12]. The incidence and prevalence of joint arthroplasty infection is increasing, with a two-fold increase in hip and knee prosthetic infections documented from 1990–2004 [17,18,19].

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The clinical impact of periprosthetic joint infection remains severe, with infection noted to be the leading cause of morbidity following joint replacement [22], the #1 cause of joint arthroplasty failure [12], and associated with a statistically increased rate of revision surgery [1]. Periprosthetic infection has been shown to carry a 2.7 – 18% mortality rate [22]. The economic impact of periprosthetic joint infection remains a significant problem, with these cases totaling three to four times the cost of uncomplicated primary arthroplasty [3,4,18]. One study estimates a cost of \$50,000 per periprosthetic infection [12], while another notes that septic revisions cost \$60,000 more than aseptic revision [1].

Peri-endoprosthetic infection for tumor reconstruction has been documented to occur in 5.7 – 15% of cases [8,10,11,23,24,27]. One series of 650 endoprosthesis cases, notes a 9.6% infection rate [7]. Another series documents the infection prevalence to increase to 43% in revision endoprosthesis cases [5], and another notes peri-endoprosthetic infection results in amputation in 23.5% of cases [27]. A thorough review of previous endoprosthesis infection case series was performed in 2010 [2]. The study found staphylococcus was most common organism among multiple case series. Factors associated with infection were myeloma, radiation therapy, poor soft tissue condition, revision surgery, and extra-articular joint resection. These studies yielded mixed recommendations on treatments and outcomes [2].

The current study aims to investigate the incidence, prevalence, risk factors, treatments, and associated outcomes of infection of lower extremity arthroplasty cases performed for the treatment of musculoskeletal tumors in order to help improve their prevention and treatment. The authors post the question: is periprosthetic infection in our bone tumor patients associated with any disease, treatment, or outcome variables that could influence management of these difficult conditions?

Patients and Methods

All musculoskeletal tumor patients treated with lower extremity tumor resection and artificial joint reconstruction over a ten year period at a single institution were retrospectively reviewed, specifically evaluating those who developed deep periprosthetic infection, as determined by the clinical diagnosis of the evaluating surgeon. Non-tumor patients and those with infection prior to reconstruction were excluded.

Table 1 describes relevant patient demographics. Four basic lower extremity reconstructions were performed af-

ter surgical treatment of benign and malignant tumors: standard femoral stem arthroplasty, proximal femoral endoprosthetic reconstruction, distal femoral reconstruction, and proximal tibial reconstruction. Infection cases were then analyzed according to multiple variables, including patient epidemiology, pathology, adjuvant therapy, surgical history, type of prosthesis, previous implant surgeries, presentation time, causative organism, original treatment modality, and subsequent infection treatment. Patients were followed according to standard oncologic protocols for a mean of 34 months (range 4 to 251 months).

Table 1. Patient Demographics

Type of Prosthesis	n	Gender (M/F)	Age (Min - Max)	Follow up (months)
Hip Endoprosthesis	147	69/78	61 (14 - 86)	13 (0.5 to 217)
Hip Standard Prosthesis	16	5/11	59 (23 - 86)	21 (0.75 to 152)
Hinged Distal Femur Endoprosthesis	125	61/64	30 (12 - 90)	87 (1.8 to 251)
Hinged Proximal Tibia Endoprosthesis	41	23/18	31 (11 - 82)	70 (4.4 to 195)
Total	329	158/171	50 (11 - 90)	34 (0.4 to 251)

Variables were then compared within the infection cohort, using the student t-test to compare means and relative risk ratio. Kaplan-Meier survival analysis was performed to evaluate both implant and patient survival. Statistical confidence was set to a 95% interval, and data analysis was performed using Graphpad® statistical software. No power analysis was performed.

Results

The overall prevalence of infection in this tumor prosthetic patient cohort was 13.1%. Proximal femoral endoprostheses demonstrated a 5.4% rate of infection, as opposed to the 12.5% rate of standard hip prostheses, 19.2% in distal femoral endoprostheses, and 22% in proximal tibial endoprostheses (Table 2). Hip prosthesis reconstructions demonstrated a 6.1% infection rate as opposed to the 20.5% rate observed in knee endoprosthetic cases, a difference that was noted to be statistically significant ($p < 0.001$). When looking at infection rates with regard to specific diagnosis, sarcomas demonstrated the highest infection rate (21.7%), which was statistically increased when compared to non-sarcoma cases ($p = 0.001$ [Table 3]). Metastatic disease demonstrated the lowest overall infection rate at 7.4%, which was statistically lower than non-metastatic disease cases ($p = 0.006$ [Table 3]). Table

4 describes the cultured pathogens associated with the infections, with Staphylococcus aureus demonstrated in 33% of culture positive specimens, and Staphylococcus epidermidis in 17%. 50% of Staphylococcus Aureus specimens were methicillin resistant.

Table 2. Overall Infection Rate by Location

Type of Prosthesis	n	Time (mo)	Infection (n)	Infection %
Hip Endoprosthesis	147	12	8	5.4
Hip Standard Prosthesis	16	18	2	12.5
Hinged Distal Femur Endoprosthesis	125	70	24	19.2
Hinged Proximal Tibia Endoprosthesis	41	53	9	22.0
Total	329	28	43	13.1

Table 3. Overall Infection Rate by Disease

Disease	n	Infection Rate (%)	P-value
Sarcoma	106	21.7	0.001
Metastatic Disease	163	7.4	0.006
Benign Bone Tumor	60	15.3	0.64

Table 4. Microbiology

Pathogens	Patients (n)
Staphylococcus Aureus	10 (5 MRSA)
Coag Neg Staphylococcus	5
Diphtheroids	3
Streptococcus	3
Enterobacter	3
Enterococcus	2
Escherichia Coli	2
Candida Albicans	1
Cryptococcus	1
No Growth (gross purulence)	9

The mean total number of surgeries performed (prior to infection) was doubled in the infection group when compared to that of the non-infected group (p= 0.005 [Table 5]). The knee endoprosthesis cases demonstrated a consistently stable incidence with time, while hip infections developed earlier, and their incidence decreased with time (Figure 1 & 2). With regard to adjuvant therapy, radiation therapy alone was noted to carry a significantly higher risk of infection (RR = 3.85, p = 0.03), as did chemotherapy alone (RR = 1.51, p =0.05). Interestingly, chemotherapy in combination with radiation was associated with a decreased rate of infection (RR = 0.66, p = 0.05 [Table 6]). With regard to the results of the final treatment modality, irrigation and debridement procedures alone (without any component exchange) were associated with 42% success at achieving remission of infection, while single stage irrigation and debridement procedures with the addition of

modular component exchange and varying degrees of suppressive antibiotics was associated with a 70% success rate. Formal two-staged implant removal, antibiotic spacer placement with subsequent reimplantation was associated with a 62% success rate, while 100% of infection cases treated with amputation resulted in remission of infection.

Table 5. Number of Associated Surgeries (prior to infection diagnosis)

# of Surgeries	Infection		No-Infection	
	n	%	n	%
1	20	45	224	78
2	15	34	50	17
3	3	7	9	3
4	2	5	1	0
5	2	5	0	0
Mean (p=0.005)	2		1	

Table 6. Infection and Adjuvant Therapy

Adjuvant	Patients	Infection Rate	Relative Risk	p-value
Chemotherapy alone	97	0.20	1.51	0.05
Radiation alone	6	0.50	3.85	0.03
Chemotherapy & Radiation	139	0.09	0.66	0.05
No Adjuvant Therapy	87	0.13	1.00	0.81

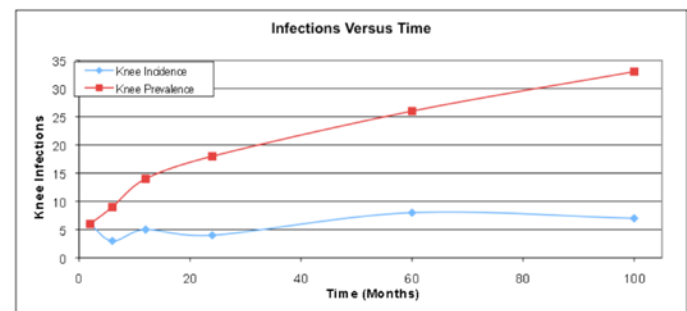


Figure 1. Incidence and prevalence of knee infections with regard to time

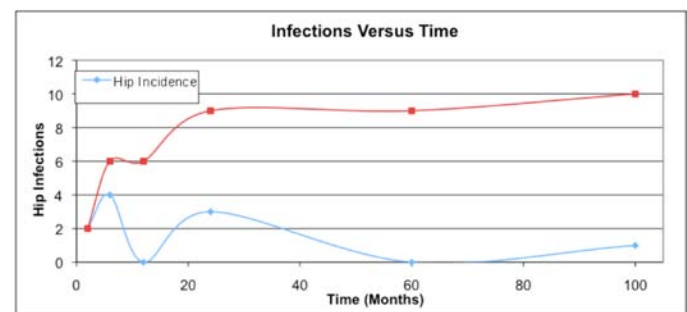


Figure 2. Incidence and prevalence of hip infections with regard to time

Figure 3 describes the overall implant survival in the entire base population, with over 70% of these implants surviving beyond a projected 20 years. Hip implants lasted longer than knee implants, when the subgroups were divided (Figure 4). Overall patient survival in the cohort hovered at roughly 40% for the long term (Figure 5), with

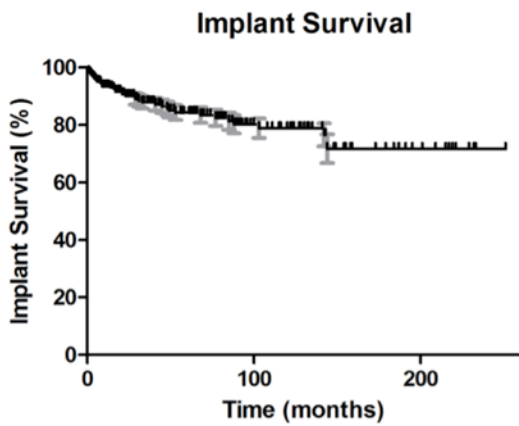


Figure 3. Kaplan-Meier curve describing overall implant survival

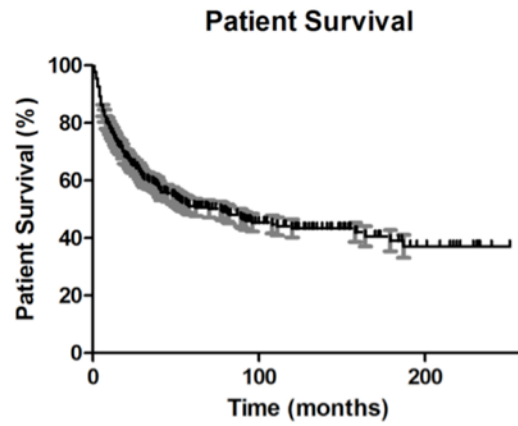


Figure 4. Kaplan-Meier curve describing implant survival with regard to location & type of implant (oncologic [endoprosthesis] vs non-oncologic [standard] implant)

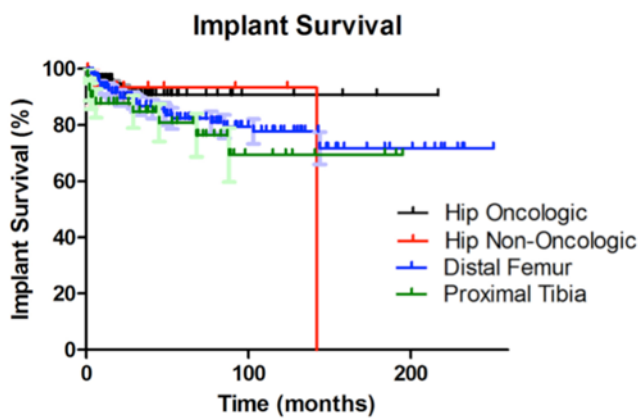


Figure 5. Kaplan-Meier curve describing overall patient survival

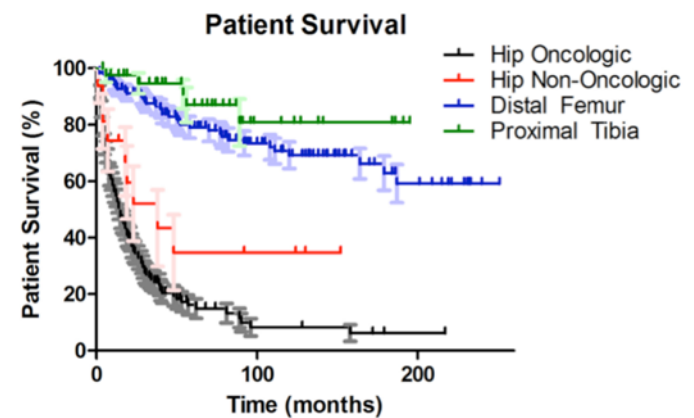


Figure 6. Kaplan-Meier curve describing patient survival with regard to location & type of implant (oncologic [endoprosthesis] vs non-oncologic [standard] implant)

knee patients surviving much longer than the hip counterparts (Figure 6). In all cases, implant survival was greater than patient survival.

Discussion

Periprosthetic infection represents a leading cause of failure, morbidity, and mortality in non-oncologic primary joint arthroplasty. Tumor prostheses are associated with increased infection rates when compared to traditional joint arthroplasty. The current study asks if periprosthetic infection in our bone tumor patients is associated with any epidemiologic, treatment, or outcome variables that could influence the prevention, diagnosis, and treatment of these conditions.

A major weakness of the study includes the lack of control and standardization of patients with multiple confounding variables with regard to their disease and treatment. For example, hip prosthesis were more often used in those with malignant diagnoses, especially metastatic disease. The decreased life expectancy seen in metastatic

disease will influence the prevalence of infection. Despite this lack of control, and relatively small numbers, statistical differences were indeed discovered with analysis of the subgroups in the cohort. The diagnosis of deep periprosthetic infection was based on the clinical judgment of the treating surgeon, and the diagnosis of initial or recurrent infection can often be unclear. The fact that all treating surgeons in the study were well versed in the clinical diagnosis and management of periprosthetic infection may mitigate this weakness.

Disease variables that were associated with infection in this tumor prosthesis series include the location and type of implant, with the knee significantly more at risk than the hip (20.5% vs 6.1% [$p = 0.0001$]). This correlates with a former study finding 23% of proximal tibial endoprosthetic reconstructions became infected [14]. The malignant diagnosis of sarcoma was associated with a statistically higher infection rate ($p = 0.001$), while those with metastatic disease demonstrated a statistically lower infection rate ($p = 0.006$). This finding contrasts previous literature citing increased infection rates with myeloma, as opposed to other tumors [14]. Most hip infections occurred in the first

year, while knee infections with same incidence at 5 years out. Previous publications show that most infections occurred early, but could be seen as late as 210 months after implantation [2]. Staphylococcus species remain the most common pathogen (50% of culture positive cases), a finding which also corresponds to the previous literature review [2].

In this study, radiation alone was associated with significantly higher infection risk (50%, RR = 3.85, $p = 0.03$), and less so chemotherapy (20%, RR = 1.51, $p = 0.05$). Several previous publications demonstrate increased infection rates with adjuvant radiation therapy [9,14,15,20]. A previous review of endoprosthesis infection case series failed to find any studies showing a correlation between chemotherapy and implant infection [2]. In the current study, chemotherapy and radiation in combination demonstrated a statistically decreased overall infection rate, likely due to the fact that their combined use often indicated underlying metastatic disease, with treatments administered at lower doses in those with shorter life expectancies. Infections were associated with significantly increased number of associated prior to development of infection ($p = 0.005$). Previous studies have also indicated infection correlates with revision surgery rates [9,14,20]. In these cases, the increased number of surgeries could be a cause or an effect of the periprosthetic infection. Irrigation & debridement with modular component exchange was noted to have similar success rates when compared to formal, extensive 2-staged procedures (70% vs 62%) in the current study. This contrasts with several studies in previous literature, which often found two stage procedures to have higher resolution rates, with single stage procedure success rates ranging from 6% to 73% [6,7,9,14,16,21].

With regard to survival, the current study's long term (> 10 year projected) implant survival was noted to be well over 70%, which correlates with recent literature regarding modular oncologic endoprostheses [28]. In our study, standard primary hip implants lasted longer than "oncologic" endoprostheses, which also correlates with previous studies. This study's highest survival was documented in proximal tibia and knee cases. This difference occurred presumably because primary tumors (benign and malignant) more commonly occurred in the knee, as opposed to the increased proportion of metastatic disease occurring in the proximal femur.

In conclusion, periprosthetic joint infection in the tumor patient occurs at a higher Incidence and prevalence when compared to traditional primary joint arthroplasty. Staphylococcus Aureus remains the most common cultured organism in these cases. Knee endoprosthetic infections can occur late, and the development of infection is associat-

ed with radiation therapy, chemotherapy, and revision surgery. Irrigation and debridement with modular component exchange may result in infection remission rates comparable to two-staged procedures.

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Surgical Stabilization of the Medial Capsulo-Ligamentous Envelope in Total Knee Arthroplasty

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Abstract

This study will evaluate an alternative method in which a four prong bone staple was used to repair the medial collateral ligament following over-release or avulsion injuries in (#6) cases during a total knee arthroplasty. The use of a four prong bone staple to repair medial collateral ligament injuries status post total knee replacement will provide satisfactory results with respect to post-operative knee stability and range of motion. Our retrospective review revealed that all six patients improved with regards to range of motion following the total knee arthroplasty. We feel that repair of the medial collateral ligament with a four-prong bone staple is a viable option after an over-release or avulsion injury sustained during a total knee arthroplasty.

Introduction

One of the more common complications of total knee arthroplasty is an intraoperative injury to the medial collateral ligament (MCL), in which there is significant loss of collateral ligament tissue with or without damage to the medial femoral condyle/epicondyle [7]. In a thorough review of the orthopedic literature, the overall incidence of this injury during total knee arthroplasty is unknown [7,9,10]. In this study, we describe a new, unreported fixation method of repairing the knee medial collateral ligament status post injury during a total knee arthroplasty using a Smith and Nephew four prong bone staple.

When researching the most current arthroplasty literature, insufficiency of the medial collateral ligament when discovered in the preoperative physical examination with varus and valgus stress testing can be treated with either soft tissue reconstruction using one of the following methods: 1.) hamstring fixation technique, 2.) achilles allograft with a calcaneal bone block and fixation with 6.5mm cancellous screws, 3) or with an implant that provides stability, not only in the sagittal but in the coronal plane as well with the use of a constrained knee construct [2,3,4,5].

The medial collateral ligament is the primary restraint to valgus stability of the knee. At around 30° of flexion, the medial collateral ligament provides 80% of the restraining force [12,13]. While in full extension, it only provides 60% of the restraining force [12,13]. A thorough understanding of the anatomy of the knee medial collateral ligament is crucial before any repair of this ligament can be performed.

The superficial medial collateral ligament otherwise known as the tibial collateral ligament is the largest struc-

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ture of the medial aspect of the knee. This structure consists of one femoral attachment and two tibial attachments. The femoral attachment has been shown to be oval in shape and on average is located 3.2mm proximal and 4.8mm posterior to the medial epicondyle [12,13]. As it courses distally, it has two tibial attachments. The first proximal attachment point is primarily to soft tissue over the semimembranosus tendon. This attachment measures an average of 12.2mm distal to the tibial joint line [11,12,13]. The distal tibial attachment of the superficial medial collateral ligament is broad and attaches directly to the bone approximately 61.2mm distal to the tibial joint line [11,12,13].

The deep medial collateral ligament is comprised of thickened tissue and is found on the medial aspect of the joint capsule. This ligament is divided into meniscofemoral and meniscotibial components. The meniscofemoral portion of the deep medial collateral ligament has a slight convex curve attachment is located 12.6mm distal and deep to the femoral attachment of the superficial medial collateral ligament [12]. The meniscotibial portion is much shorter and thicker. It attaches just distal to the edge of the articular cartilage of the medial tibial plateau and is found 3.2mm distal to the medial joint line and 9.0mm proximal to the proximal tibial attachment of the superficial medial collateral ligament [11,12].

Literature supports the fact that the medial collateral ligament has an excellent capacity to heal after injury. In the opinion of our lead surgeon (JM), the use of a constrained hinged knee construct and/or the implantation of allograft tendon to repair the medial collateral ligament injury is not needed. Our hypothesis is that the use of a four-prong bone staple (Smith and Nephew) to repair the medial collateral ligament injury status post total knee replacement will provide satisfactory clinical results with regards to post-operative stability and range of motion.

Methods and Materials

All demographic and intraoperative data were retrieved, as part of a prospective database, on all patients (758) undergoing total knee arthroplasty at the senior author's (JM) institution since 2008. Our present study included all of the patients who underwent total knee arthroplasty performed by the senior author (JM) between the dates of 08-01-2008 to 02-15-2013 and who sustained an intraoperative injury to the medial collateral ligament as documented in the database with confirmation in the operative report. Patients with prior MCL injuries were excluded. These operative reports were carefully examined and confirmed that the injury to the medial collateral ligament occurred during

over-release or avulsion of the medial collateral ligament in attempts to balance a tight varus/valgus knee.

The same surgical techniques along with cruciate retaining implants were used by the senior author (JM) during each case. All the operations were performed by the senior author or under his direct supervision. The author used a straight midline incision, measuring four fingerbreadths above the superior pole of the patella to the medial aspect of the tibial tubercle. The standard medial parapatellar incision was used as the exposure technique in all the knees.

After eversion of the patella and flexion of the knee, a self-retaining knee strap was used to maintain the knee in flexion. A scalpel was then used to transect and remove the anterior cruciate ligament. Attention was then placed on the tibia, where the subperosteal plane was developed beneath the deep medial collateral ligament. Bovie electrocautery was then utilized to continue the dissection from anterior to posterior. Careful attention was taken as the dissection proceeded in the posterior direction to ensure that the insertion site of the medial collateral ligament is not violated.

Bilateral weight-bearing radiographs were available in the room to assess for varus/valgus deformity. If the knee was neutral to slight varus, the dissection was stopped at the midcoronal plane. If the knee had a more severe varus deformity, the dissection was extended to the posterior medial corner of the knee. Carefully attention was placed on retractor placement during the entire procedure in attempts to decrease iatrogenic injury.

Injury of the medial collateral ligament was identified after insertion of the trial implants and during balancing of the knee in both flexion and extension. At this time, the defect whether at the femoral origin or the tibial insertion point was repaired using a Smith and Nephew four prong bone staple. Medial collateral ligament defects on the femoral side were thought to develop due to the nature of the osteoporotic bone. Here the cortical bone is so thin and the cancellous bone underneath is so soft; the demineralized bone almost fractures off and lifts away during manipulation of the knee. This portion was repaired by first by fully extending the knee joint and localizing the area of liftoff/fracture. The four prong bone staple (Smith and Nephew) was then impacted into the femoral epicondyle. Of note, the staple dimensions are 16mm in width and 22mm in length, therein it does not come into contact with the femoral or tibia component.

If the medial collateral ligament deficiency was noted on the tibial side, it was thought to occur due to over-release during soft tissue balancing. This deficiency was then repaired by first placing a varus stress to the knee followed by flexing the knee to 60°. A Kocher clamp was then used

to advance the ligament distally and laterally to an isometric point on the tibia and the four prong bone staple (Smith and Nephew) was then malleted into place.

The senior author (JM) once again evaluated the balance of the knee with the trial implants in to ensure optimal balance. The final implants were placed and the knee was once again thoroughly evaluated as in all total knee arthroplasty's.



Figure 1. An example of the Smith and Nephew four-prong staple used for repair.



Figure 2. Post-operative radiographs following four-prong staple fixation on the femur side.



Figure 3. Post-operative radiographs following four prong staple fixation on the tibia side.

In the acute post-operative setting, these patients were treated as a normal total knee arthroplasty, with no additional precautions. Each patient was placed in a continuous passive range of motion machine immediately and each proceeded to participate fully with physical therapy with no restrictions on weight-bearing status. All patients received 10mg of Xarelto orally once a day for 3 months for deep venous thrombosis prophylaxis. Upon discharge from the hospital, each patient continued with physical therapy in an outpatient setting or attended a skilled nursing facility for rehabilitation.

The 2011 Insall Modified Knee Society score will also be utilized as a tool to evaluate each patient in the post-operative setting. This system has been developed by the Knee Society to provide a more current and stringent evaluation form. The system is subdivided into a knee score that rates only the knee joint itself and a functional score that rates the patient's ability to walk and climb stairs [1]. The dual rating system eliminates the problem of declining knee scores associated with patient infirmity. This score was obtained before the surgery and after the surgery to assess pain and function following the total knee arthroplasty.

Results

We retrospectively reviewed the medical records of the 758 patients (380 knees) who underwent primary TKA from August of 2008 to February of 2013. Intraoperative medial collateral ligament disruption or stretching was recognized when there was unexpected medial laxity in a patient with no preoperative medial instability. There were (#6) patients with recognized intraoperative medial collateral ligament injury (0.79%). Six knees in six patients were available for follow up at a mean of 75 days following surgery (range 30 days to 120 days). The mean age of each patient was 68 years (range 54 to 76) and the mean age at the time of surgery was 66 years. Two of the patients were male and four were female. Four of six of our patients were considered to be obese according to the body mass index scale with a score of 30 or greater. Three of the knee replacements were right sided and three were left sided. The pre-operative diagnosis for five of the patients was osteoarthritis with the other having traumatic arthritis.

After careful thought and discussion, it was found that all of our injuries occurred secondary to either over-manipulation of the osteoporotic femur or by the sharp osteotomes used for the subperiosteal elevation in attempts to balance the varus/valgus knee. Four of the medial collateral ligament injuries were on the tibial side and two were on

the femoral side. No patients in this study were required to wear any bracing devices after the surgery and no patients reported any instability of the knee joint. Each patient ambulated into the clinic at the last follow up visit with no assistance needed. None of these patients had to undergo any form of revision surgery.

In the post-operative setting, each patient was scheduled to follow up at the senior author's clinic for orthopedic and radiographic evaluation. At the first follow up visit, the range of motion of the knee was evaluated and documented with the use of a goniometer along with assessment of standing knee radiographs to determine whether an acceptable overall alignment was achieved. Each of the radiographs was reviewed by the lead surgeon and an upper level orthopedic resident, revealing well aligned knee prosthesis with no presence of radiolucent lines, lytic lesions, or component migration.

The Knee Society clinical rating score was officially performed at the pre-operative visit and at the initial follow-up appointment. Of note, stability of the medial collateral ligament was assessed on physical examination by gently applying a valgus stress to the knee at both 0° and with the knee flexed to 30°. Grading of valgus stress testing was defined as follows: A) 0 defined as 0-3mm of opening, B) +1 defined as 3-5mm of opening, C) +2 defined as 5-10mm of opening and D) +3 defined as >10mm of opening. Failure in our study was defined as >5mm of opening at either 0° or 30° with absence of a firm endpoint with stressing of the knee.

At follow up examination, the senior author (JM) evaluated each of the patients and found that each exhibited an increase in range of motion along with no laxity noted upon varus/valgus stress testing of the affected knee at both 0° and 30°. Table 1 reviews the pre and post-operative knee laxity, range of motion, and Knee Society score.

The average preoperative knee range of motion was 1.6° of extension to 92° of flexion. Upon comparison, the average postoperative range of motion was 3° of extension to 95.6° of flexion. The average grade of preoperative valgus laxity of the affected knee was (+) 1.6, but this decreased to zero laxity after total knee arthroplasty and

tive and postoperative Knee Society scores were 23.6 and 75.8 respectively. Each patient had a significant increase in Knee Society score, with an average score increase of (+) 52.2.

Conclusion

Any disturbance of the medial collateral ligament during a total knee arthroplasty is a serious complication and should be treated with the utmost respect. It has been well documented in the orthopedic literature that all coronal plane instabilities can result in the need for revision total knee arthroplasty with the use of a constrained device [8,9,10]. In addition, these patients actually function well with respect to the knee society score. The downfall of this treatment option is placing a constrained revision component into a primary total knee. Our study is the first to address this issue with only the use of a small, unconstrained, minimally invasive implant device.

In our study of six patients, four of them who sustained medial collateral ligament injuries were obese according to the body mass index scale. In a past article by Winiarsky, Barth, and Locke, they concluded that the rate of perioperative complications was significantly higher in obese patients. According to their study, 22% of their obese patients had a wound complication, 10% had an infection, and 8% had an avulsion of the medial collateral ligament.

In comparison, 2% of the knees in their non-obese control group had a wound complication, 0.6% had an infection, and none had an avulsion of the medial collateral ligament [15]. This is an important factor to consider when performing a total knee arthroplasty on the obese population in the future.

There are limited studies dedicated to the treatment of intraoperative injuries to the medial collateral ligament without the use of a constrained device [2,3,4,5]. Most of the current literature recommends using a constrained implant instead of direct repair [8,9,10]. In our study, we evaluated (#6) cases in which a four-prong bone staple (Smith and Nephew) was used to repair the medial collateral ligament following either over-release or avulsion injury dur-

Age	BMI	Sex	Injury Side	Pre-operative ROM	Pre-operative laxity	Post-operative ROM	Post-operative laxity	Pre-operative Knee Score	Post-operative Knee Score	Change
72	31	Male	Right Tibia	0-75	(+)2	0-90	0	15	86	(+)71
51	19	Female	Right Tibia	0-75	(+)3	5-100	0	2	77	(+)75
66	44	Female	Left Femur	0-80	(+)1	0-94	0	25	67	(+)42
72	30	Male	Left Tibia	0-125	(+)1	6-105	0	36	68	(+)32
65	26	Female	Left Tibia	10-120	0	3-100	0	27	76	(+)49
72	30	Female	Right Femur	0-90	0	4-103	0	37	81	(+)44
Avg: 66.3				Avg: 92	Avg: 1.2	Avg: 95.6	Avg: 0	Avg: 23.6	Avg: 75.8	Avg: (+)52.2

medial collateral ligament fixation. The average preopera-

ing total knee arthroplasty.

Two limitations of our case series are 1) the small number of patients (#6) and 2) the lack of a control group of which to compare. Another limitation of our study is the short follow up period, which averaged 75 days post-surgery. This study could be stronger if these patients were followed for a longer period of time to assess function and pain control, which will be an area that this research paper could expand on in the future. However, we remain cautiously optimistic that this mode of fixation will provide adequate fixation over the life of the arthroplasty.

Our retrospective review revealed that all six patients improved with regards to range of motion and Knee Society score following the total knee arthroplasty. Post-operative varus and valgus stress testing of the affected knee found no laxity. Once again, no patients in this study were required to wear any bracing devices after the surgery and no patients reported any instability of the knee joint. None of these patients had to undergo any form of revision surgery. Due to these results, we feel that repair of the medial collateral ligament with a four-prong bone staple (Smith and Nephew) is a viable option after an over-release or avulsion injury during a total knee arthroplasty.

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