Research Article **AJORR (2021) 4:20**

American Journal of Orthopedic Research and Reviews
(ISSN:2637-4730)

Single Stage Knee Arthroplasty Revision Surgery, Our Experience with Eleven Cases and Review of the Literature

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ABSTRACT

Introduction:

Knee replacement is a widely performed and very successful procedure for the management of knee arthritis. Nevertheless, it is postulated that a total of 2-5% of primary and revision total knee arthroplasties (TKAs) is infected every year [1,2]. Despite the low incidence, the absolute numbers of prosthetic joint infections (PJIs) are growing, owing to an increased number of replacement surgeries, and are associated with significant morbidity and socioeconomic burden [3,4].

Although several definitions of PJI exist, Musculoskeletal Infection's Society (MSIS) definition is based on strict criteria and is one of the most used [5].

Patients with certain risk factors have an increased risk to develop PJI [6,7]. Risk factors include presence of systemic or local active infection in an arthritic knee; previous operative procedures in the same knee, diabetes mellitus, malnutrition, smoking, alcohol consumption, co-morbidities, and immunosuppression; end-stage renal disease on hemodialysis, liver disease, intravenous drug abuse, and low safety operative room environment.

PJIs are classified according to the depth of infection, to superficial and deep infections. Superficial infections are limited to the incision and superficial tissues, while deep infections, that involve deep layers, may occur up to one year postoperatively, and influence surgical management strategy. Timing of

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How to cite this article:
Andreas X. Papadopoulos , Athanasios Karageorgos, Charalampos Matzaroglou, Spyros A. Syggelos, Christos A. Papadopoulos, Ioannis D. Gelalis. Single Stage Knee Arthroplasty Revision Surgery, Our Experience with Eleven Cases and Review of the Literature.American Journal of Orthopedic Research and Reviews, 2021; 4:20.

eSciPub LLC, Houston, TX USA.
Website: https://escipub.com/

infection is also an important factor in guiding treatment. PJIs are classified to acute postoperative, within a month of the index procedure, acute haematogenous, presenting with acute symptoms in a previously well – functioning joint, and late chronic, where infection develops later than one month postoperatively [8].

Management of PJI's is mainly surgical, reserving conservative treatment for patients unable to undergo surgery [9]. Surgical options include debridement and retention of the prosthetic implants (DAIR), two – stage exchange revision, single – stage exchange revision, permanent resection arthroplasty, and finally amputation as the last measure [10]. DAIR is a viable option in early stages of acute infections, but established chronic infections necessitate more radical methods.

Two – stage revision that was originally described by Install [11], secondly modified through the development of static spacers [12], and then articulating spacers [13], is considered the gold standard of TKA infection management [14]. A large volume of literature reports successful eradication of PJIs in more than 90% of patients using this approach [15,16,17]. Nevertheless, this procedure is costly, time-consuming, develops stiffness, arthrofibrosis, impairs mobility and increases inpatient stay. Single-stage revision arthroplasty for infection was first described in the 1980s [18, 19], has gained popularity for use in selected patients [20]. Infection control using this approach is achieved in 67% to 95% of patients [21, 22, 23, 24]. Furthermore, it is associated with less patient morbidity, improving functional outcome and reducing cost [25, 20].

This paper seeks to systematically review the results of using single – stage revision arthroplasty for chronic infection of TKAs. Furthermore, we report our experience with eleven cases of chronic knee arthroplasty infection, which were treated with the aforementioned technique.

Material and Methods:

Literature search:

A comprehensive search was performed on medical electronic databases (PubMed / Medline; Embase Science Direct; Cochrane Library; Google Scholar; Scopus; CINAHL and other non – indexed citations) by two of the authors from the 1st January 1992 to the 1st October 2020. Our main aims were to: 1) determine the reinfection rate, 2) evaluate functional outcome through validated scores. Medical literature was reviewed for the terms 'periprosthetic joint infection', 'single – stage exchange', 'direct exchange arthroplasty', 'knee joint infection', 'knee revision arthroplasty', 'prosthesis – related infection', 'revision knee replacement'.

Selection criteria:

We evaluated studies investigating the use of single – stage knee revision surgery for infected TKA. We excluded those that concerned surgeries for aseptic loosening, periprosthetic fractures and persistent pain without any evidence of infection. Furthermore, studies with incomplete data, without available full text, or not well reported, were also excluded. Finally, abstract, case reports, conference presentations, reviews, editorials and expert opinions were not included.

Case series:

We present data of eleven patients (6 females and 5 males), ages from 55 to 77 (median: 64.7) years, who were treated with single – stage revision knee arthroplasty due to chronic prosthetic infection of the knee, between 2005 and 2019. All patients had undergone primary knee arthroplasty suffering from osteoarthritis, in another health facility. They were referred to the Orthopaedic Department outpatient clinic, complaining for pain, decreased mobility, and signs of inflammation, such as local temperature raise, swelling and redness. Time after index procedure was 4 to 38 (mean: 11.3) months All patients presented the symptoms within the first 12 months after index procedure. They all had treated for long time with broad spectrum oral antibiotics, with relapsing and remitting symptoms.

The patients underwent serological and radiographic investigation, radionuclide bone scan (Tc-99m) and pre-operative aspiration and culture. All patients were presented with elevated erythrocyte sedimentation rate (ESR) and C -

reactive protein (CRP). Synovial white blood cells (WBC/mm^3) ranged from 9500 to 10200 (mean: 9800/mm^3) with neutrophils range from 66% to 75%. Radiographic evaluation did not reveal rapid progressive loosening or osteolysis in any case. Technetium – Tc99m isotope bone scan had performed to all patients, and it was positive in all cases, indicating high vascularisation in the area, due to inflammation. Preoperative aspiration was positive in 2 out of 11 cases and *Staphylococcus aureus* was isolated in both patients. Patients' demographics follow up, outcomes, and main findings are summarized in Table 1.

Table I: Patients demographics

No	Age	Time from index procedure (months)	ERC (0-20 mm/1h)	CRP (0-0,5 mg/dl)	(WBCs / PMN%) synovial	Pus joint presence	Pre op synovial culture	Post op synovial culture	Skin fistula	Pre op KSS	Post op KSS	Follow up
1	65	38	38	62	9800 (68% PMN)	yes	negative	S epidermidis	no	40	85	1 year
2	55	7	35	1,8	9500 (66% PMN)	yes	negative	negative	no	36	97	6 months
3	62	8	42	6,2	10100 (70% PMN)	yes	S aureus	S aureus	no	39	83	12 years
4	61	4	55	7	9700 (72% PMN)	yes	negative	S epidermidis	no	42	90	10 years
5	76	12	35	5,5	9500 (68% PMN)	yes	negative	negative	no	50	101	10 years
6	67	17	35	15	9800 (70% PMN)	yes	negative	S epidermidis	no	44	82	3 years
7	58	8	39	2	9600 (69% PMN)	yes	negative	negative	no	52	95	18 months
8	64	8	38	7,3	10000 (72% PMN)	yes	S aureus	S aureus	no	45	80	5 years
9	60	5	52	8	10200 (75% PMN)	yes	negative	S epidermidis	no	39	75	8 years
10	77	10	35	8,3	9800 (73% PMN)	yes	negative	negative	no	53	99	4 years
11	67	8	38	7,5	9600 (68% PMN)	yes	negative	S epidermidis	no	42	83	2,5 years

All patients underwent single-stage revision knee arthroplasty. Surgical technique consisted to removal of the old skin scar. The joint was then opened and debridement performed to remove all infected soft tissue, including a complete synovectomy. Multiple bacteriological and tissue samples were taken (more than 6). The infected prostheses were removed and also the cement when evident, using ronqeurs and curettes. Complete bone debridement took place, including intramedullary reaming. The joint was washed out with copious quantities of normal saline (6 litres and more) using pulsatile irrigation, packed with povidone-iodine-soaked swabs, and wound edges temporarily approximated for thirty minutes. Appropriate antibiotics were administrated intravenously, according to the sensitivities established pre-operatively, and tourniquet was deflated. The surgical area was desterilized and redraped, and the surgical team rescrubbed and exchanged the entire set of surgical instruments. New components were introduced using gentamicin loaded commercial cement (PMMA). To avoid reduce cement spacer's fatigue resistance; we did not mix it with any antibiotic powder. The wound was closed over a suction drain, which was retained for at least 2 days. Parenteral post-operative antibiotics were administrated for 5 to 7 days according to sensitivities and then a course of oral antibiotics for 6 weeks. Oral antibiotics consisted of ciprofloxacin, clindamycin and rifampicin. Four cases that presented negative pre and post-operative cultures were treated for *staphylococci* species.

Results

A total of 14 studies were included in this review, amounting to 421 knee revision surgeries. The demographic details, study designs, and outcomes are included in Table 2. Of the 14 studies that met the inclusion criteria; two were prospective cohort studies, six were retrospective cohort studies, three were retrospective case series, one was observational prospective cohort, one

was descriptive retrospective, and one was retrospective case control.

Table 2: Study designs and Outcomes

Author	Study design	Follow up	Patient demographics	Outcomes
Ji et al. (2017) [26]	Retrospective Case Series	5y	n=7 Gender 5F, 2M Mean age: 66.5 +/-10,1	RR=29.6% FO: HSS 46 preop to 78 post op
Jenny et al. (2016) [27]	Retrospective Case Control	2 y	Intervention: 54 Control group: 77 Mean age: 70 (45-90) Gender: 68F, 63M	RR= Intervention: 15% Control: 22% FO: KSS over 160 No difference between groups
Zahar A et al. (2016) [28]	Retrospective Cohort	10y	n= 46 Mean age: 70 (60-81) Gender: Not reported	RR= 7% FO: HSS 35 pre op to 69.9 post op
Haddad et al. (2015) [29]	Retrospective Cohort	2y	n=28 Mean age: 65 (45-87) Gender: 14M, 14F	RR: 0% FO: KSS higher in single - stage group vs two – stage group (mean: 88 vs 76) Pre op KSS: 32 in single – stage group
Tibrewal et al. (2014) [30]	Prospective Cohort	10y	n=50 Mean age: 66,8 Gender: 33F, 17M	RR:2% FO: OKS 14.5 Pre op to 34,5 Post op
Klatte et al. (2014) [31]	Retrospective Cohort	7y	n=4 Mean age: 67.75 +/- 13.3 Gender: 1F, 3M	RR: 25% FO: KSS from 51 Pre op to 75 Post op
Baker et al. (2013) [32]	Prospective Cohort	7 months	n=33 Mean age: 69.4 +/- 10.7 Gender: 15F, 18M	RR: 21% FO: OKS from 15 Pre op to 25 Post op
Jenny et al. (2013) [33]	Observational Prospective Cohort	3y	n=47 Mean age: 72 (45-93 Gender: 27F, 20M	RR: 12% FO: KSS from 42 Pre op to >150 in 56% of pts. Post op
Singer et al. (2012) [23]	Descriptive Retrospective	3y	n=57 Mean age: 72 +/- 8.7 Gender: 30F, 27M	RR: 15% FO: KSS 72 Post op OKS 27 Post op
Whiteside et al. (2011) [34]	Retrospective Cohort	5.1y	n=18 Mean age: 69 +/- 6 Gender: 11F, 7M	RR: 5.5% FO: Mean KSS 84 +/- 8 at 5y Post op
Mereddy et al. (2011) [35]	Retrospective case series	2y	n=22	RR: 0% FO: WOMAC, PCS / Significant improvement
Sofer et al. (2005) [24]	Prospective Cohort	18,5 months	n=15	RR: 6%

In our review reinfection rate ranged from 0% to 29.6%. The range of follow up was from 7 months to 10.2 years (mean: 6 years), and the range in the number of cases were from 4 to 57 patients. The scoring system used in our included studies were Hospital for Special Surgery Knee score (HSS), Knee Society Score (KSS), Oxford Knee Score (OKS), Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), and Photographic Chondropathy Score (PCS). The most commonly used function score was KSS (50%), followed by OKS (21.5%). All included studies reported successfully functional outcomes. Nevertheless, due to heterogeneity of the functional outcome, scores were not possible to perform a reliable statistical comparison. Studies that used KSS concluded to an improvement above 75 grades to the final follow up and two of them reported more than 150 grades in the majority of patients. Studies using OKS reported improvement to 25 grades and more postoperatively.

None of the 11 patients who were treated with single-stage knee revision in our institution, developed recurrence of infection after mean follow up of 5.2 years. The functional outcome of all

patients was evaluated using the knee society scoring system (KSS), which was recorded preoperatively and at the last follow up. The patients improved after revision surgery from 43.8 preoperatively (range 36-53) to 88.2 postoperatively (range 75-101). Radiographic evaluation did not evident loosening or osteolysis at final follow up.

Discussion

Despite the relatively low rates of PJIs after TKAs, they remain a leading cause of revision surgery, due to the increasing number of knee arthroplasty performed yearly for an aging population [15]. PJIs are associated with significant morbidity, mortality and increased health care costs due to prolonged hospitalization and multiple surgical procedures [3, 4]. Eradication of chronic PJIs is achieved with exchange of prosthesis, and treatment for long periods with parenteral and oral antibiotics. Although two-stage exchange arthroplasty, is considered the 'gold standard', single-stage techniques is gaining in popularity due to decreased morbidity, cost and hospitalization. Furthermore, eradication rates are similar if not better than these of two-stage arthroplasty.

Strict patients' selection is considered a critical issue for successful outcomes in single-stage revision arthroplasty. Recommendations by the International Society for Infectious disease for single-stage arthroplasty include: no need for bone graft, an aggressive debridement of all infected tissue, satisfactory soft tissue envelope, absence of difficult to treat microorganisms, and a bacteria that is sensitive to antibiotic cement [14]. Haddad et al. [29] reported reinfection rate 0% in highly selected patients. Nevertheless, Jenny et al. [27] reported that patients' selection does not improve outcome and Zahar et al [28] obtained high eradication rate in a study including patients irrespective of negative host factors (ASA, BMI, sinus tracts or flap requirement). Ji et al. [26], and Klatte et al. [31] treated patients after fungal infection with acceptable outcomes after long follow up.

Standardize surgical technique is another important factor which may lead to reliable results in terms of infection management. Basic stages of single-stage revision surgical technique consisted of: careful soft tissue debridement and excision of fistula when present; complete removal of all implant and cement; careful bone and soft tissue debridement including posterior capsule; collection of soft tissue samples for culture and histopathology; copious fluid and chemical irrigation; and temporal wound closure soaked in sterilized liquid. After this first surgical step, the surgical area is desterilized and redraped, the surgical team is rescrubbed, and the entire set of surgical instruments is exchange. Reconstruction of the joint is carried out using antibiotic loaded cemented knee implants. Finally, the wound is closed over suction drain, which is retained for few days. Ji et al. [26], Zahar et al [28], Haddad et al. [29], introduce new implants with antibiotic-impregnated cement, including supplementation with appropriate antibiotics, according to previous cultures and sensitivities. Jenny et al. [33], used pedicle musculocutaneous flap when necessary. Tibrewal et al [30], administrated intravenously (IV) antibiotics, while he was deflating the tourniquet after temporal wound closure. Whiteshide et al. [34], performed wound irrigation using saline solution of vancomycin, polymyxin and bacitracin and did not use cemented implant. They used instead, daily intraarticular vancomycin infusion for 6 weeks after operation via 2 Hickman catheters remained to the knee.

Postoperative antibiotic medication is another issue of debate. Antibiotic-impregnated bone cement is in common use in almost all studies, but high antibiotic synovial concentrations the first 2 days, fall to very low levels after 72 hours [36, 37]. Synovial fluid antibiotic concentration is less than 20% of serum concentration when gentamicin is used [38]. In cases of resistant bacteria or gram-negative organisms, the levels are too low to be effective [39]. The International Society for Infection Disease recommends 2 weeks of IV therapy followed by 6 months of oral therapy for prosthetic knee joint infection [14]. There was no consensus regarding the duration of antibiotic therapy in this pool of international studies as it ranged from 10-17 days IV without prolonged

oral therapy [28], to intraarticular infusion for 6 weeks with only two doses of IV infusion [34]. Close observation of inflammatory markers (CRP, ESR) and consultation by infectious disease experts are mandatory to postoperatively treat these patients properly.

Following standardized surgical technique and appropriate postoperative antibiotic treatment, single-stage knee revision that exchanges surgery has demonstrated high eradication rate, ranged from 70% to 100%, in this review. A meta-analysis comparing the outcomes following one and two stage revisions of infected TKRs revealed rate of re-infection 7,6% and 8,8% respectively [40]. Postoperative clinical outcomes of knee and range of motion were similar for both strategies in the aforementioned meta-analysis. Functional outcome in our review demonstrated significant improvement in all studies, even though statistical comparison was not possible due to heterogeneity of the functional outcome scores. The 11 patients, who treated in our institution, demonstrated 100% eradication rate and functional improvement from 43.8 preoperatively to 88.2 postoperatively, used KSS.

Our review reveals satisfactory outcomes for single-stage revision in the management of infected TKR concerning eradication rate and functionality. Although strict patient selection criteria have demonstrated successful results, good results were also reported even when these criteria were not applied. Single-stage outbalanced two-stage procedures in high risk patients, due to their reduced hospitalization and the need of single operation. The main limitation of this systematic review is that most of the studies are retrospective, with no clinical randomized controlled trials indentified. However, this review summarizes and highlights the evidence in the literature for this demanding topic. Large clinical randomized control trials are needed for more objective analysis for the success rate and patient's functionality.

Acknowledgement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

The manuscript has not been previously published and in not being considered for publication elsewhere.

The authors have no conflicts of interest to declare that are relevant to the content of this article.

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