Tips & Tricks: Soft Tissue Reconstruction of the Complicated Knee Arthroplasty: Principles and Predictors of Salvage

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Introduction

Nearly 700,000 knee joints are replaced annually, making total knee arthroplasty (TKA) one of the most common procedures performed in the United States (US)[1]. TKA is effective, safe, and significantly improves quality of life in patients suffering from end stage joint disease[2,3]. However, the procedure is not without complications. These typically arise from loosening of implants, mechanical failure, infection, or compromise of the surrounding soft tissues[4,5]. These complications can be devastating, resulting in failure of the prosthesis, knee fusion, or even amputation[6,7]. While several authors have shown that plastic surgeons can help improve outcomes in TKA's compromised by soft-tissue deficits[8-12], the optimal timing and position of the reconstructive surgeon within the stages of revision TKA has not been firmly defined. In this study, we aimed to: 1) elucidate the ideal role of soft-tissue reconstruction within the time course of knee salvage after a compromised TKA, and 2) identify key factors that affect outcomes, primarily long term retention of a knee prosthesis.

Materials and Methods

A retrospective review of all patients who underwent total knee arthroplasty and subsequent soft tissue reconstructive surgery by the senior author (S.J.K) was performed from 2008 to 2016. Relevant clinical and operative data was collected including medical comorbidities, surgical history, culture data, and follow-up.

The primary outcome of interest was TKA salvage, defined as retention of the prosthesis at last follow up; secondary outcomes included subsequent knee fusion and above knee amputation. Patients were subdivided based on the status of their knee at the time of presentation to our institution: Group 1 patients did not have an open knee wound upon presenting to our hospital, receiving all orthopedic care within the institutional health system, Group 2 had an active wound that was referred from outside of our institution. We hypothesized that patients were referred to our tertiary care center from outside hospitals would have a more complex surgical history and would be at higher risk for ultimate prosthesis failure.

Results

Initially, 77 patients with 79 compromised TKAs were identified. Five patients were excluded for inadequate records, leaving 71 patients with 73 reconstructed knees.

Salvage

Forty-five knee prostheses (61.6%) included in our study were successfully salvaged. Patients who were referred from outside hospitals and presented with active wounds or infected prostheses (Group 2) suffered a higher rate of adverse outcomes, including a significantly higher rate of prosthesis failure (Table 1). Success of salvage was negatively correlated with the total number of knee surgeries prior to plastic surgery intervention (OR = 0.68, p = 0.011). There was a trend toward decreased likelihood of salvage with increasing time (days) from diagnosis of soft-tissue compromise to index plastic surgery procedure (OR = 0.99, p = 0.09) and increasing debridements between diagnosis of wound complication and definitive soft-tissue reconstruction (OR=0.765, p = 0.093). In Group 1 patients, each additional trip to the OR after wound complication significantly decreased the likelihood of salvage (OR = 0.43, p = 0.03). Similarly, each additional day between diagnosis of complication and index plastic surgery operation decreased likelihood of salvage (OR = 0.98, p = 0.09) (Table 2).

Culture data also proved to be a significant determinant of prosthesis salvage. Nearly all (93.3%) patients who had negative cultures were able to achieve TKA salvage, whereas only 52.6% of patients with positive cultures were salvaged (p = 0.006). The lowest rate of TKA salvage occurred in the presence of gram-negative organisms (47.1%, p = 0.029), with gram-positive infections having a slightly higher rate of success (52.7%, p = 0.01). Patients with positive wound cultures at the time of the definitive soft tissue reconstruction had a significantly lower rate of salvage (40% vs 71%, p = 0.028) (Table 3).

Knee fusion and Amputation

Risk of knee fusion was significantly increased in the setting of a gram-negative infection (20.6% vs 2.9%, p = 0.05). The risk of amputation was significantly increased with each additional

Table 1. Operative Outcomes

	All		Group 1 (n = 31)		Group 2 (n = 42)		
	n	%	n	%	n	%	
Salvage	45	61.6	23	74.2	22	53.7	$p < 0.05$
Failure	28	38.4	8	25.8	20	46.3	$p < 0.05$
Fusion	8	11.0	3	9.7	5	11.9	
Amputation	18	24.6	6	19.4	12	28.6	

Table 2: Temporal factors affecting outcomes

All patients	Effect	p value
Each additional knee surgery prior to definitive reconstruction	Decreased risk of salvage (OR = 0.68)	0.011
	Increased risk of amputation (OR = 1.42)	0.02
Number of knee washouts prior to definitive reconstruction	Decreased rate of salvage for each additional washout (OR = 0.77)	0.093
Time (days) from diagnosis to index PRS procedure	Decreased salvage rate (OR = 0.99)	0.09
Group 1	Effect	p value
Each additional knee surgery prior to definitive reconstruction	Decreased salvage rate (OR = 0.58)	0.03
	Increased risk of amputation (OR = 1.63)	0.05
Each additional knee washout prior to definitive reconstruction	Decreased salvage rate (OR = 0.43)	0.03
	Increased risk of amputation (OR = 2.25)	0.06
Time (days) from first orthopedic washout to index PRS procedure	Decreased salvage rate (OR = 0.98)	0.09

operation prior to attempt at definitive reconstruction (OR = 1.42, p = 0.02), especially in Group 1 (Amputation OR = 1.63, p = 0.05). Group 1 patients who had more serial debridements also had a higher rate of amputation (OR = 2.25, p=0.06). Positive wound cultures at the time of definitive reconstruction tended to increase the risk of amputation (45% vs. 19% p = 0.06). (Table 3)

Discussion

Soft-tissue complications after primary TKA are relatively rare[13] and more common in patients with history of multiple knee surgeries or medical comorbidities [4,8,11,12,14]. In the setting of compromised prostheses, staged revision arthroplasty has shown to be successful in up to 93% of cases[15]. However, in the remaining knees who fail a revision arthroplasty, likelihood of successful knee salvage is astonishingly low. Maheshwari et al. showed that in patients who require a secondary treatment cycle after reinfection of their revised knee replacement, the likelihood of success is as low as 32.2%, with a 16% risk of amputation[16]. Thus, every effort should be made to achieve a successful outcome at the initial revision attempt. Based on our results, there is an important benefit to early, proactive soft-tissue management, immediate plastic surgery involvement upon suspected infection, and minimizing the amount of procedures prior to reconstruction, and the value of an orthoplastic approach to limb salvage. Furthermore, patients who are referred from outside institutions with active wounds and/or infections had a significantly higher risk ultimate prosthesis failure and therefore must be treated aggressively and without delay (Table 1).

Table 3: Microbiology factors affecting outcome

Joint Space Culture (any timepoint)	Positive: 40% salvage Negative: 73.7% salvage	p = 0.006
GNR culture:	GNR +: 47.1% salvage GNR −: 73.7% salvage	p = 0.029
GPC culture:	GPC +: 52.7% salvage GPC −: 88.2% salvage	p = 0.01
Culture (at definitive reconstruction)	Positive: 40% salvage Negative: 71% salvage	p = 0.028
	Positive: 45% amputation Negative: 19% amputation	p = 0.06

We suggest three simple but important reconstructive principles when approaching the challenge of a compromised TKA: 1) obtain adequate soft-tissue coverage of a clean and aseptic knee joint with the least operations and in the timeliest fashion possible: "time is tissue" 2) employ an orthoplastic approach[17-19] for complex patients and carefully consider prophylactic soft tissue coverage in patients who require TKA and have tenuous soft tissues. The former relies on prompt operative intervention and only after the joint space is completely free of contamination should definitive soft-tissue reconstruction occur. Soft tissue reconstruction follows the reconstructive ladder with local fasciocutanous flap coverage preferred as a first line, followed by local muscle flaps, and lastly, free tissue transfer (Figure 1). Patients in need of a joint replacement but with fragile soft tissues or multiple scars around the knee should be referred to a plastic surgeon prior to joint replacement for consideration of prophylactic soft tissue coverage either in advance or at the same time as arthroplasty.

The timing of reconstructive efforts relative to the diagnosis of the soft-tissue complication proved an important factor in determining ultimate success. Our data support that earlier intervention by a plastic surgeon and fewer procedures leading up to definitive soft tissue reconstruction of the knee improve long term salvage. Choosing a method of soft tissue reconstruction is done on a patient to patient basis and depends on the past surgical history, local tissue quality and availability, and orthopedic requirements. With this in mind, the tenets of the reconstructive ladder remain the basis of the technical decision-making algorithm[4]. The most common definitive soft tissue reconstruction in our cohort was the medial gastrocnemius flap (MGF), a local muscle flap that is our workhorse for coverage of the knee. This flap provides abundant muscle tissue on a reliable vascular pedicle (medial sural artery) and can be re-elevated at a later time for access to the knee joint. Harvest of the gastrocnemius muscle, however, does confer functional consequences. Daigeler et al. showed that harvest of the gastrocnemius muscle results in decreased force of ankle plantar flexion by approximately 23.8% [20]. Nevertheless, this functional deficit is a minor sacrifice for patients with compromised knee joints who are in danger of losing ambulation or worse, amputation. When the soft tissue deficit is so great that the MGF is deemed inadequate to provide a supple soft tissue envelope around the knee joint, the surgeon must consider free tissue transfer. Our group prefers the use of a free fasciocutaneous flaps, particularly the anterolateral thigh (ALT) flaps, because they provide abundant pliable soft tissue without functional morbidity of muscle flaps.

Culture data also had significant impact on the likelihood of success, with any positive operative culture decreasing rate of salvage by 33.7% (p = 0.006). Although the presence of gram negative organisms portended a lower overall salvage rate (47.1% vs 73.7% without GNRs, p = 0.029) the presence of gram positive organisms reduced the rate of salvage to a greater degree (by 35.5%). (Table 2) Finally, the presence of positive cultures at the time of definitive reconstruction both decreased salvage (-31%, p = 0.028) and increased the rate of amputation (+26%, p = 0.06). This is in contrast to the recent data published by Leckenby et al who showed that the presence of infection did not influence outcomes [21]. This may be due to their institutional protocol which includes specialists in orthopedic infectious disease as an integral component of the treatment team, a prospect now being considered at our own institution.

Figure 1: The most common method of soft tissue reconstruction in our series was the gastrocnemius flap **(A)**, seen here being reflected over the knee joint prior to inset and split thickness skin graft. **(B)** When local tissue and local muscle flaps are not available or insufficient to reconstruct soft tissue around the knee, free tissue transfer (anterolateral thigh flap) may be the last chance to prevent an above knee amputation.

Conclusions

In the setting of a complicated total knee arthroplasty, our data supports prompt intervention by the reconstructive surgeon in order to optimize genicular soft tissues and maximize prosthesis salvage. Operative goals include achieving negative joint cultures in the fewest possible procedures prior to definitive soft tissue closure. In patients with tenuous soft tissues and a need for future knee arthroplasty, careful consideration should be given to prophylactic soft tissue coverage about the knee. Timely intervention is the key to success in salvage of TKA.

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