



Soft-tissue coverage for wound complications following total elbow arthroplasty

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Background: In patients with total elbow arthroplasty (TEA), the soft-tissue around the elbow can be vulnerable to soft-tissue complications. This study aims to assess the outcomes after soft-tissue reconstruction following TEA.

Methods: We retrospectively included nine adult patients who underwent soft-tissue reconstruction following TEA. Demographic data and disease characteristics were collected through medical chart reviews. Additionally, we contacted all four patients that were alive at the time of the study by phone to assess any current elbow complications. Local tissue rearrangement was used for soft-tissue reconstruction in six patients, and a pedicle flap was used in three patients. The median follow-up period was 1.3 years (range, 6 months–14.7 years).

Results: Seven patients (78%) underwent reoperation. Four patients (44%) had a reoperation for soft-tissue complications, including dehiscence or nonhealing of infected wounds. Five patients (56%) had a reoperation for implant-related complications, including three infections and two peri-prosthetic fractures. At the final follow-ups, six patients (67%) achieved successful wound healing and two patients had continued wound healing issues, while two patients had an antibiotic spacer *in situ* and one patient underwent an above-the-elbow amputation.

Conclusions: This study reports a complication rate of 78% for soft-tissue reconstructions after TEA. Successful soft-tissue healing was achieved in 67% of patients, but at the cost of multiple surgeries. Early definitive soft-tissue reconstruction could prove to be preferable to minor interventions such as irrigation, debridement, and local tissue advancement, or smaller soft-tissue reconstructions using local tissue rearrangement or a pedicled flap at a later stage.

Keywords: Arthroplasty; Elbow; Surgical wound dehiscence; Surgical wound infection; Reconstructive surgical procedures

INTRODUCTION

Total elbow arthroplasty (TEA) is a treatment option in patients with advanced rheumatoid arthritis, osteoarthritis, post-traumatic arthritis affecting the elbow, and complex distal humerus fractures [1]. However, the soft-tissue envelope at the elbow can be of

poor quality, particularly after prior surgery, increasing the risk of soft-tissue- and implant-associated complications, especially at the olecranon and in patients with systemic inflammatory disease [2,3]. Soft-tissue reconstruction using local tissues, pedicled flaps, or free flaps can be utilized to treat or prevent these complications.

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The most common options for soft-tissue reconstruction of the elbow include local tissue rearrangements and pedicled flaps (anconeus, brachioradialis, radial/ulnar forearm, or medial/lateral arm), but free flaps have also been reported (anterolateral thigh, groin, or latissimus dorsi) [3-6]. Infections, wound dehiscence, flap necrosis, seroma formation, and hematomas are potential complications after soft-tissue reconstruction of the elbow, with wound dehiscence being the most common [7,8]. Additionally, wound healing issues may develop due to periprosthetic infections. The implant is generally explanted at the time of soft-tissue reconstruction, but there are many factors involved in such decision making.

Reports on the outcomes of soft-tissue reconstruction in the setting of TEA are limited. Studies with short-term follow-ups have shown the short-term benefits of soft-tissue reconstruction, but longer follow-up complication rates remain high, which is in line with most total elbow arthroplasties [2,3,7,9]. This study aims to assess the soft-tissue related outcomes and the arthroplasty related outcomes after soft-tissue reconstruction following TEA.

METHODS

We conducted this study in compliance with the principles of the Declaration of Helsinki. The study's protocol was reviewed and approved by the Partners Human Research Committee (study number. 1999P008705). Verbal informed consent was obtained in cases of telephonic follow-ups, while informed consent was waived in cases of retrospectively identified patients that were not successfully contacted for follow-ups.

After Institutional Review Board approval, we identified patients that had an International Classification of Diseases 9th edition procedure code, 10th edition procedure code, or current procedural terminology (CPT) code for soft-tissue reconstruction in combination with a CPT code for TEA (Supplementary Material 1). All patients identified with both sets of codes ($n = 30$) that were treated at a single institutional system including five urban hospitals from the January 1, 2000, to the March 1, 2018, were verified through medical chart reviews. We included all adult patients that underwent soft-tissue reconstructions using local tissue rearrangement or a pedicled flap following TEA. Local tissue rearrangement was defined as adjacent tissue transfers involving rearranging or transferring local areas of the skin along with underlying subcutaneous tissues to cover the defects. Complex wound closure with local tissue advancement was not classified as soft-tissue reconstruction and these patients were not included. Twenty patients were excluded upon manual review be-

cause they were miscoded and did not undergo TEA or soft-tissue reconstruction using a flap, while one patient was excluded because a free flap was used for initial soft-tissue coverage, resulting in a final total of nine included patients.

Data regarding patient-, treatment-, and disease characteristics were collected through medical chart reviews. A nonhealing wound was defined as incomplete wound healing per secondary intention requiring additional treatment. Wound dehiscence was defined as the reopening of a previously closed wound requiring additional treatment. A wound infection was defined as an infection of the operated elbow requiring antibiotic treatment and confirmed using microbiological cultures and serologic markers. Serologic markers positive for active infection were defined as a C-reactive protein concentration higher than 13.5 mg/L or an erythrocyte sedimentation rate higher than 22.5 mm/hr, with these data being available in seven patients [10-12]. Differentiation between a wound and implant infection was based on the clinical judgement of the treating physician. Reoperation was defined as any unplanned surgery to the ipsilateral elbow, more specifically, reoperations were subdivided into soft-tissue related (revision surgery for soft-tissue complications) or TEA related (replacement or removal of one or more components of the implant) reoperations. Follow-up time was calculated as the time from soft-tissue reconstruction to final clinical or telephone follow-ups.

The patients that were alive at the time of the study ($n = 4$) were contacted by letter or phone to complete questionnaires regarding additional treatment at other institutions and the status of wound healing. We were able to contact all four patients. Long-term outcome data were collected and managed through Research Electronic Data Capture (REDCap, Vanderbilt University, Nashville, TN, USA) tools hosted at our institution. This is a secure web-based application designed for data capture and management of research studies [13].

Study Population

The nine patients that were included had a median age of 69 years (range, 21-78 years) at the time of soft-tissue reconstruction and the majority of the patients were female ($n = 6$). The median follow-up was 1.3 years (range, 6 months-14.7 years). One patient (case 7) did not undergo reoperations, but also had no records of follow-up and was deceased at the time of the study. In total, five patients were deceased at the time of the study. The median follow-up of the remaining patients was 8.0 years (range, 1.1-14.7 years).

Six patients underwent TEA for rheumatoid arthritis, one patient underwent an osteosarcoma resection followed by TEA, one

patient underwent a TEA for a distal humerus fracture with underlying rheumatoid arthritis, and one patient exhibited a non-union of a closed distal humerus fracture. Five patients had bilateral total elbow replacements, but no patients underwent bilateral soft-tissue reconstruction. The elbow of the dominant limb was treated in five patients. Prosthesis designs included Discovery (Zimmer Biomet, Warsaw, IN, USA; n=4), Coonrad-Morrey (Zimmer Biomet; n=2), and Capitellar Condylar (Stryker, Kalamazoo, MI, USA; n=1). In two patients, the make of the prosthesis was unknown (Table 1, Figs. 1-3).

After TEA, but prior to soft-tissue reconstruction surgery, all patients had at least one reoperation (range, 1–13), including implant replacement (complete TEA or single component), open reduction and internal fixation, secondary wound closure with local tissue advancement (but no reconstruction requiring soft-tissue rearrangement), triceps repair, radial nerve neurolysis and multiple tendon transfers, elbow scar contracture release, excision of heterotopic ossification, irrigation and debridement (I&D), and ulnar nerve neurolysis and bursectomy (Table 2). Soft-tissue reconstruction was performed at a median of 9.0 months (range, 1 month–27.6 years) following TEA. Indications for soft-tissue reconstruction included an infected nonhealing wound (n=8) and an ischemic nonhealing wound of the soft-tissue covering the olecranon combined with a seroma (n=1). Six out of eight infections were confirmed with microbiological cultures or serologic markers (Table 3). All infections received antibiotic treatment. The implant was exposed in three patients (cases 1, 5, and 7), but was not exchanged at the initial soft-tissue reconstruction. The olecranon was exposed in three patients (cases 2, 4, and 8). Local tissue rearrangement was used in six patients (cases 1, 2, 4–6, and 9), and a pedicled flap was used in three patients (cases 3, 7, and 8). In two patients, soft-tissue reconstruction was performed in multiple stages (cases 4 and 5) with a flap delay in the first surgery and subsequent inset in a second or

third surgery. The defect size at the elbow ranged from 2 to 144 cm² with this information being retrievable from the charts in seven patients (Table 3).

RESULTS

Following soft-tissue reconstruction, seven patients (78%) underwent reoperation and five patients underwent more than one



Fig. 1. An anteroposterior radiograph of case 2 showing a total elbow implant in place.

Table 1. Demographics

Case	Sex	Age (yr)	Diagnosis	Implant type	Surgery on dominant limb	Smoker	Diabetes	Workers' compensation
1	Female	61	Rheumatoid arthritis	Unknown	No	Yes	No	No
2	Female	78	Rheumatoid arthritis	Biomet discovery	Yes	No	No	No
3	Female	74	Rheumatoid arthritis	Capitellar condylar	Yes	No	No	No
4	Female	77	Rheumatoid arthritis	Biomet discovery	Yes	No	No	No
5	Male	74	Fracture	Coonrad-Morrey	Yes	No	No	No
6	Female	69	Rheumatoid arthritis	Coonrad-Morrey	No	No	No	No
7	Male	68	Rheumatoid arthritis and fracture	Unknown	Yes	Yes	Yes	No
8	Male	62	Rheumatoid arthritis	Biomet discovery	No	Yes	No	No
9	Female	21	Osteosarcoma	Biomet discovery	Unknown	No	No	No

reoperation (range, 0–4). The median time to reoperation was 4.6 months (range, 1.4 months–1.9 years). Two patients (22%) had successful secondary soft-tissue coverage with a single soft-tissue reconstruction and did not require any further operations (cases 7 and 9) (Table 4).

Four patients (44%) had a reoperation for soft-tissue complications after the primary reconstruction (cases 1–3, and 8), including dehiscence or nonhealing of infected wounds. One patient initially underwent local tissue advancement for wound closure

(case 8) and four patients eventually underwent additional soft-tissue reconstruction or skin grafts: local tissue rearrangements (cases 2 and 8), a full-thickness skin graft from the medial arm (case 3), and a radial forearm pedicled flap (case 1) were used for secondary soft-tissue reconstructions. Additional local tissue rearrangement (case 8) and a pedicled muscle flap, covered by a full-thickness skin graft from the lateral arm (case 3), were used for tertiary soft-tissue reconstruction. One patient (case 3) required a fourth operation for soft-tissue reconstruction for which a split-thickness skin graft from the anterolateral thigh was used. A free flap was not used in any of the patients. At the final follow-up, one patient had an above the elbow amputation (case 2), and two patients had persisting nonhealing wounds (cases 1 and 3).

Median implant survival following soft-tissue reconstruction was three years (range, 2 weeks–14.6 years). There was no patient



Fig. 2. A lateral radiograph of case 4 showing a total elbow implant in place.



Fig. 3. A lateral radiograph of case 5 showing a total elbow implant in place.

Table 2. Operations before soft-tissue reconstruction

Case	No. of operations	Procedure (n)	Time to reconstruction (yr)
1	13	I&D (5), TEA replacement and triceps repair (2), TEA replacement (2), bushings replacement (1), triceps repair (1), wound closure with local tissue advancement (1), TEA removal and placement of antibiotic spacer (1)	27.60
2	2	I&D (2)	0.13
3	1	Elbow scar contracture release (1)	8.28
4	6	I&D (6)	0.05
5	4	I&D (3), excision of ossification (1)	0.80
6	2	I&D (2)	11.80
7	5	Wound closure with local tissue advancement (3), TEA replacement (1), I&D (1)	0.71
8	2	Ulnar nerve neurolysis and excision of bursitis (1), I&D (1)	0.32
9	2	TEA replacement (1), I&D with placement of antibiotic bead (1)	Unknown

I&D: irrigation and debridement, TEA: total elbow arthroplasty.

Table 3. Treatment

Case	Indication	Microbial culture	Serologic infection marker	Antibiotic treatment	Bone/implant exposed	Soft-tissue donor	Reconstruction technique	Defect size (cm ²)
1	Nonhealing infected wound	CoNS	Unknown	Yes	Implant	Local	Tissue rearrangement	Unknown
2	Nonhealing infected wound	CoNS	Positive	Yes	Olecranon	Local	Tissue rearrangement	2
3	Nonhealing infected wound	<i>Nocardia farcinica</i>	Positive	Yes	No	Muscle	Pedicle	12
4	Ischemic nonhealing wound	Unknown	Unknown	No	Olecranon	Local	Tissue rearrangement	144
5	Nonhealing infected wound	Unknown	Negative	Yes	Implant	Local	Tissue rearrangement	50*
6	Nonhealing infected wound	MRSA	Positive	Yes	Implant	Local	Tissue rearrangement	60*
7	Nonhealing infected wound	Unknown	Positive	Yes	Unknown	Fasciocutaneous	Pedicle	Unknown
8	Nonhealing infected wound	Negative	Negative	Yes	Olecranon	Fasciocutaneous	Pedicle	48*
9	Nonhealing infected wound	<i>Staphylococcus epidermidis</i>	Positive	Yes	No	Local	Tissue rearrangement	32

CoNS: coagulase-negative staphylococci, MRSA: Methicillin-resistant *Staphylococcus aureus*.

*Covering soft-tissue measured instead of defect.

Table 4. Outcomes

Case	No. of reoperations	Time to reoperation (mo)	Soft tissue complication	Implant revision	Implant survival (mo)	Deceased	Follow-up time (yr)
1	3	2.84	Yes	No	0.51	Yes	0.51
2	2	17.87	Yes	Yes	17.39	Yes	1.54
3	3	2.03	Yes	No	115.64	No	1.10
4	1	23.51	No	Yes	22.88	No	10.65
5	2	4.36	No	Yes	4.24	Yes	0.52
6	1	5.64	No	No	157.47	Yes	0.97
7	0	NA	No	No	Unknown	Yes	-*
8	4	1.35	Yes	Yes	54.14	No	5.27
9	0	NA	No	No	175.20	No	14.72

NA: not applicable.

*No records of reoperations or follow-up.

where the implant was replaced during soft-tissue reconstruction. There were five patients (56%) with a reoperation for implant-related complications, including three infections (cases 2, 5, and 6) and two peri-prosthetic fractures (cases 4 and 8). One patient was successfully treated with an I&D (case 6), while the other four patients required implant revision. Eventually, one patient had the humeral component exchanged (case 4) due to a peri-prosthetic fracture and the entire TEA was removed and replaced with an antibiotic spacer in three patients (cases 2, 5, and 8). At the final follow-ups, six patients still maintained their arthroplasty, of which one was revised after soft-tissue reconstruction (case 4), while two patients had an antibiotic spacer *in situ* (cases 5 and 8) and one patient had an above the elbow amputation (case 2). Other elbow related symptoms at final orthopedic follow-up included pain, weakness, instability, stiffness, and a flail elbow (Fig. 4).

DISCUSSION

This study aimed to report the outcomes of soft-tissue reconstruction following TEA. All nine patients in this study had multiple surgeries after TEA (range, 1–13) that were eventually complicated by an infection, wound dehiscence or nonhealing wound, and subsequently treated with soft-tissue reconstructions. However, despite these efforts, initial soft-tissue reconstruction was unsuccessful in seven patients. Four patients underwent additional surgery for soft-tissue complications and five patients had implant-related reoperations. At the final follow-ups, soft-tissue healing was achieved in six patients (67%), while two patients had continued wound healing issues and one patient had an above-the-elbow amputation.

This study was limited by several factors. First, soft-tissue reconstruction is uncommon in patients with TEA. In a large database from five urban hospitals using coding searches followed by

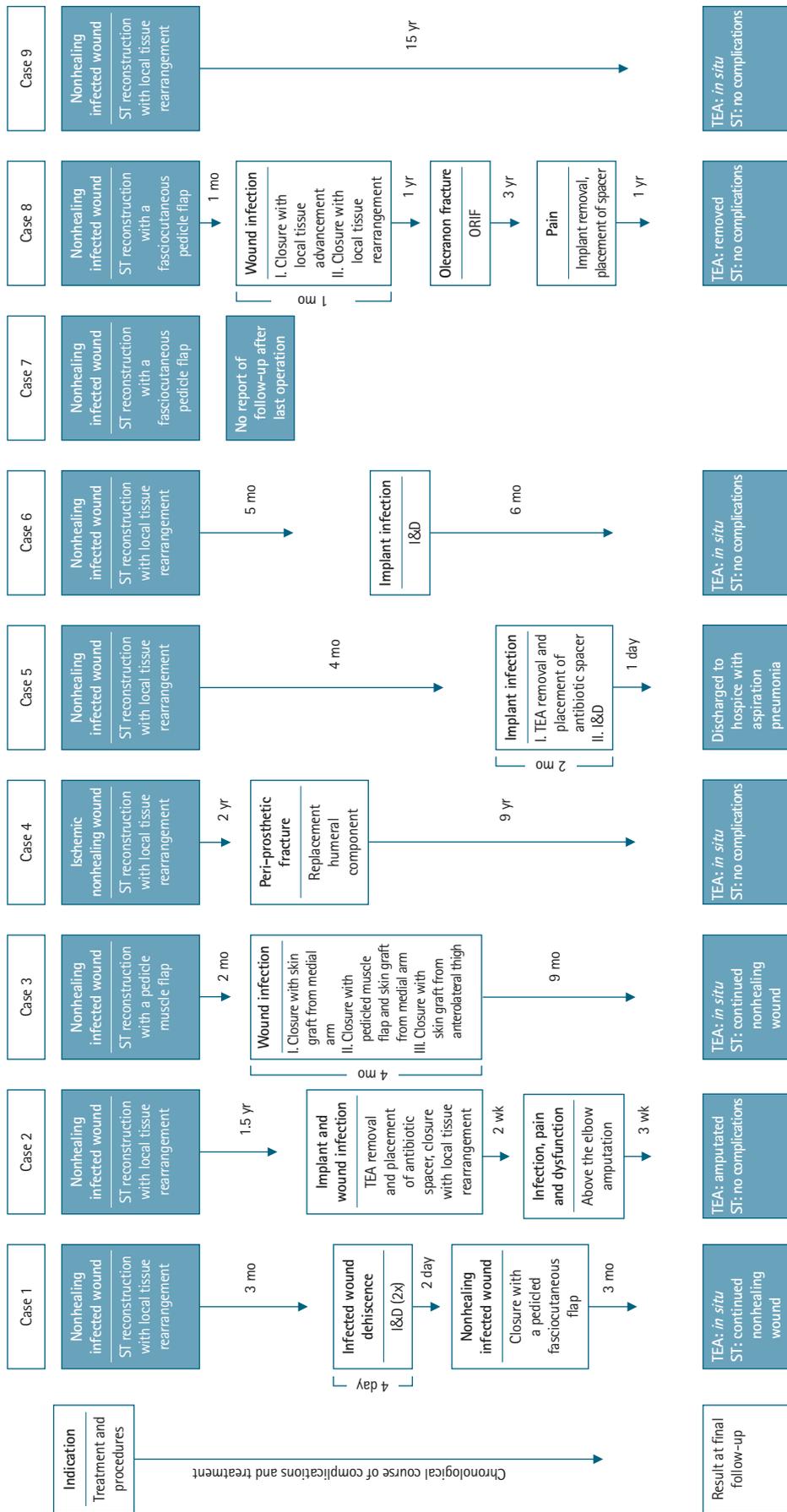


Fig. 4. Treatment timeline. ST: soft-tissue, I&D: irrigation and debridement, TEA: total elbow arthroplasty, ORIF: open reduction and internal fixation.

manual reviews, we were able to identify nine patients. It is possible that there were cases in which soft-tissue reconstructions were performed at the time of initial TEA, but this was not coded and would not be identified in our searches. Due to the small cohort, we could not perform a meaningful statistical analysis. Second, only four patients were alive at the time of this study and could be contacted for follow-ups. However, for the remaining patients, follow-up data was obtained retrospectively. Therefore, the results were dependent on coding accuracy and completeness of the medical charts. Furthermore, patients were initially treated with TEA between 1977 and 2009 leading to a variation in treatment, especially considering the evolving surgical and rehabilitation techniques (particularly in microsurgery and soft-tissue reconstruction, as well as implant design). There were also notable differences between the patients in our series in the time from initial surgery to soft-tissue reconstruction, the number of operations before soft-tissue reconstruction, the type of reconstruction used, and treatment by different surgeons. Last, we reported implant and soft-tissue related outcomes separately. However, the two are often related and differentiation was based on clinical judgements.

Our data contrasts two case series that report successful soft-tissue reconstructions using pedicle or rotation flaps after TEA in all patients [3,7]. However, their mean follow-up was 6 months and 26 months, compared to 4.4 years in our study. Our data suggests that long-term complication rates after soft-tissue coverage of TEA are likely higher (78%). Two studies reported long-term outcomes after soft-tissue reconstruction for TEA related complications [2,9]. Kim et al. [2] reported reoperations in 60% of the patients (3/5) treated with a pedicled radial forearm flap at a mean follow-up of 88 months. One patient received a free flap from the anterolateral thigh and did not have a complication. The mean age was 41 years and none of the patients had rheumatoid arthritis. In contrast, the reoperation rate after soft-tissue reconstruction in our cohort of older patients with rheumatoid arthritis was higher (78%). Okamoto et al. [9] reported the long-term outcome of one 84-year-old female with rheumatoid arthritis that underwent soft-tissue reconstruction after TEA. At a 3-year follow-up, there were no complications.

The high reoperation rate (78%) in our cohort suggests that soft-tissue coverage using delayed attempts at local tissue rearrangement or a pedicled flap may be insufficient in these patients, particularly if there has been prior failure of soft-tissue closure. In total knee arthroplasty, as well as in severe elbow trauma, soft-tissue coverage using a free flap provides positive results, and it is the practice of the senior author to be increasingly ag-

gressive about providing durable soft-tissue coverage with a definitive flap early on, prior to the development of soft-tissue complications [5,14-17]. We hypothesize that initial soft-tissue coverage of TEA using a free flap may reduce the reoperation rate. Furthermore, in six patients, an initial attempt was made to treat wound dehiscence surgically (I&D or local tissue advancement) without definitive soft-tissue reconstruction, but this was unsuccessful in all patients (cases 1, 2, 4, 5, 7, and 8). Eventually, successful soft-tissue coverage was achieved in four out of six of these patients (cases 4, 5, 7, and 8), but multiple surgeries were needed in all four patients to reach a stable result. In three patients, soft-tissue reconstruction was the primary surgical treatment of wound dehiscence (cases 3, 6, and 9). This was successful in two of the three patients, of which one who had to undergo more than one surgery (case 6). This trend suggests that the early recognition of soft-tissue problems, early consultation with a reconstructive surgeon, and initial, aggressive soft-tissue reconstruction instead of minor interventions may reduce the reoperation rate.

Early flap coverage before or during total joint replacement has been suggested in total knee arthroplasties for patients at a higher risk of soft-tissue complications. In total knee arthroplasty, older age and rheumatoid arthritis have been associated with wound healing complications [18]. Andres et al. [19] found that complications were similar between the patients that underwent “prophylactic” coverage and those who underwent a salvage procedure with flap coverage. However, in the salvage group, three patients eventually had an above-the-knee amputation compared to none in the group with “prophylactic” soft-tissue coverage. In general, poor soft-tissue quality and delayed wound healing have been reported in older patients and patients with rheumatoid arthritis [20-22]. Considering the high complication rate in the setting of soft-tissue compromise, early soft-tissue reconstruction at the time of TEA may be preferable in select patients if preservation of the prosthesis is preferred rather than resection arthroplasty.

This study reports high complication rates after soft-tissue coverage for wound complications following TEA, specifically in older patients with rheumatoid arthritis. Successful soft-tissue healing was achieved in 67% of patients, but at the cost of multiple surgeries. At final follow-up, six out of nine patients had a TEA in place, of which one was revised. Two patients had an antibiotic spacer, and one patient underwent an above-the-elbow amputation. Early soft-tissue reconstruction at the time of TEA may be considered for high-risk patients. When soft-tissue issues occur, early recognition, early consultation with a reconstructive surgeon, and definitive soft-tissue coverage procedures may aid

in the prevention further sequelae. More research is required to further clarify the decision making in complicated cases.

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SUPPLEMENTARY MATERIAL

Supplementary materials can be found via <https://doi.org/10.5397/cise.2021.00409>.

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