Skin Grafts Provide Durable End-bearing Coverage for Lower-extremity Amputations With Critical Soft Tissue Loss

Tyler Kent, MD; Chengla Yi, MD; Meryl Livermore, MD; Philip F. Stahel, MD, FACS

Abstract: Lower-extremity amputations in the presence of soft tissue loss represent an unresolved conundrum because surgeons must consider sacrificing bone length to obtain adequate soft tissue coverage. Local flaps and microvascular soft tissue transfers are established strategies for maintaining residual limb length. However, the use of skin grafts remains controversial due to the presumed inferiority compared with flaps with regard to enabling prosthetic fitting and full weight bearing. The current study was designed to test the hypothesis that split-thickness skin grafts represent a safe and feasible option to preserve bone length in lower-extremity amputations with critical soft tissue loss.

The long-standing dogma that lower-extremity amputations should be performed at the lowest possible level dates back to landmark studies from the 1970s. This notion was more recently confirmed by the large-scale Lower Extremity Assessment Project multicenter trial. Multiple surgical procedures for soft tissue reconstruction have been described to allow preservation of residual limb length using local or remote soft tissue flaps and other techniques. However, the use of split-thickness skin grafts for the salvage of lower-extremity amputations with skin loss remains controversial, and the historic perception that adequate prosthetic fitting may not be successfully accomplished with skin grafts was challenged recently.

The current study was designed to test the hypothesis that split-thickness skin grafts represent a safe strategy to provide end-bearing durable skin for soft tissue loss in lower-extremity amputations.

Materials and Methods

A retrospective review of a prospective database was performed at a single academic Level I trauma center between January 1, 2000, and December 31, 2011, to identify all patients who underwent skin grafting for the coverage of lower-extremity amputations. Inclusion criteria consisted of skeletal maturity older than 18 years with a lower-extremity amputation independent of etiology (e.g., trauma, vascular, and gangrene infection), whose residual limb was managed by split-thickness skin grafting for definitive wound closure.

Outcome parameters consisted of the incidence of complications related to wound-healing problems, skin graft breakdown, superficial or deep infection, and any complication that may require an unplanned revision surgery after the final skin-grafting procedure. All outcome parameters were pulled from a real-time prospective Quality Assurance database, as described in detail elsewhere. This study was approved by the institutional review board of the University of Colorado.

Results

A total of 202 lower-extremity amputations were performed between January 1, 2000, and December 31, 2011. Of these, 9 patients (6 men and 3 women) were identified...
with lower-extremity transtibial or below-knee amputations (n=8) or traumatic above-knee amputations (n=1) covered by split-thickness skin grafts for definitive wound closure. The latter patient had bilateral traumatic above-knee amputations, of which the left side was associated with a critical soft tissue loss (Figure), whereas the contralateral right side was amenable to delayed primary wound closure.

Mean age of the patient cohort at the index procedure was 42.7±16.3 years. The underlying conditions leading to lower-extremity amputations consisted of nonsalvageable Gustilo-Anderson type IIIb or IIIC open tibia or femur fractures and primary traumatic amputations (n=4), diabetic gangrene (n=1) and gangrene secondary to frostbite (n=3), and peripheral vascular disease with an uncontrolled postoperative infection (n=1). Vacuum-assisted closure (KCI Inc, San Antonio, Texas) was used in all cases for conditioning of the soft tissues until skin graft closure.24

Mean hospital length of stay was 31.1±12.4 days. The patients required a mean of 6.9±2.6 operative procedures from the time of initial amputation to definitive wound closure by skin grafting. After full healing of the skin grafts, patients were referred to the amputee bracing clinic for conditioning of the residual limb and fitting of temporary and definitive prosthetics (Figure). Mean time from skin grafting to first prosthesis fitting was 61.2±24.3 days. All patients achieved independent ambulation without the need for assistance after definitive prosthetic fitting within a mean of 157.3±77.2 days. None of the skin-grafted end-bearing residual limbs required surgical revision, and the complication rate was 0 of 9 cases, based on the outcome parameters outlined in the Materials and Methods section. Demographic data for patients included in this study are provided in the Table.

**Discussion**

This study supports the long-debated notion that skin grafts represent a safe and viable option for definitive wound closure in lower-extremity amputations. In the cohort of 9 patients with amputations managed by split-thickness skin grafts, prosthetic fitting and unrestricted end-bearing was accomplished in the absence of postoperative complications.

The conundrum of maintaining appropriate limb length while providing adequate soft tissue coverage continues to represent a significant dilemma for the treating surgeon.26 Independent of the surgical technique, preservation of the knee and adequate residual limb length is of utmost importance in lower-extremity amputations to ensure good functional outcomes.6,27,28 Therefore, multiple surgical techniques of soft tissue reconstruction have been described to achieve preservation of adequate residual limb length.9,16

Despite the undebated notion that local or free microvascular flaps provide high-quality end-bearing stumps, multiple limitations exist for these techniques,6,16 including a high degree of microsurgical skills required for performing such sophisticated procedures, the resulting donor-site morbidity, and the individual risk factors and comorbidities that may render a specific subset of patients poor candidates for microvascular flaps and free tissue transfers.29,30

Split-thickness skin grafts have had a bad reputation for many decades due to the presumed inferiority in providing a durable end-bearing stump, a notion that was mainly based on anecdotal reports and outdated studies from the 1970s and 1980s.17,18 The historic dogma regarding lower-extremity amputations discouraged the use of skin grafts for coverage of weight-bearing surfaces because they were thought to be too fragile to withstand the strain of prosthetic wear. However, this unjustified notion has been challenged by more recent data from the pertinent peer-reviewed literature, implying excellent mechanical stability, partial restoration of protective sensation, and excellent functional outcomes after split-thickness skin grafting of the residual limb.19,22

To allow for safe prosthetic fitting, soft tissue coverage of the lower-extremity amputation stump must fulfill multiple requirements. The skin must be durable to help counter direct and indirect shearing forces, have reasonable contour and thickness to allow for proper prosthetic fit and comfort, and retain protec-
tive sensation to allow for safe prosthesis wearing. Recent innovations in prosthetic materials and development have made it possible for less-than-optimal skin to tolerate the strain of prosthetic wear. In the current study, split-thickness skin grafts were applied successfully for preservation of the knee joint (below-knee amputations; n = 8) or for maintenance of adequate femoral length after critical traumatic soft tissue loss after a traumatic above-knee amputation (n = 1). In all patients, the skin grafts proved to be sufficiently durable, allowing patients to achieve independent prosthetic mobility in the absence of any skin graft-related complications requiring a surgical revision (Table).

The use of skin grafts for wound closure requires a good-quality underlying bed of viable granulation tissue. In the current study, this goal was achieved by wound conditioning with vacuum-assisted closure in all patients prior to final skin grafting. All 9 patients had a successful prosthetic fitting within an average of 2 months after skin grafting and had an excellent functional outcome at an average final follow-up of 22 weeks.

The main limitations of this study include the retrospective nature of the study design, the small patient population (n = 9), and the lack of long-term follow-up data at 1 year or longer. The latter shortcoming limits the interpretation of the data regarding the long-term durability of skin grafts because a valid argument could imply that skin grafts may be associated with an increased long-term skin breakdown and higher incidence of revision prosthetic fitting compared with residual limbs covered by a genuine skin envelope. Future prospective studies with longitudinal study design must address this ongoing controversy with a higher level of confidence.

**CONCLUSION**

The use of skin grafts on residual lower-extremity limbs does not appear to limit a patient’s ability to achieve independence with ambulation with full weight bearing and safe prosthetic fitting at short-term follow-up. Despite the above-mentioned limitations in study design, the current data support the notion that skin grafts are sufficiently durable to allow for effective mobilization and should be considered a valid salvage option for lower-extremity amputations with critical soft tissue loss.

**REFERENCES**


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**Table**

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*Abbreviation: STSG, split-thickness skin graft.*

*At another hospital.*