

Skin problems in individuals with lower-limb loss: Literature review and proposed classification system

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Abstract—Problems with skin integrity can disrupt daily prosthesis use and lead to decreased mobility and function in individuals with lower-limb loss. This study reviewed the literature to examine how skin problems are defined and diagnosed and to identify the prevalence and types of skin problems in individuals with lower-limb loss. We searched the literature for terms related to amputation and skin problems. We identified 777 articles. Of the articles, 90 met criteria for review of research methodology. Four clinical studies met our selection criteria. The prevalence rate of skin problems was 15% to 41%. The most commonly reported skin problems were wounds, abscesses, and blisters. Given the lack of standardized definitions of skin problems on residual limbs, we conclude this article with a system for classification.

Key words: amputation, epidemiology, lower-limb loss, prosthetic limb, rehabilitation, residual limb, review, skin diseases, skin integrity, skin problems.

INTRODUCTION

Problems with skin integrity can disrupt the daily use of a prosthetic limb and interfere with the independence and lifestyle of individuals with lower-limb loss. Biomechanical factors involved in the interaction between a prosthetic limb and skin interface, including distribution of weight, shear force, moisture, and temperature, can lead to skin problems [1–3].

Skin problems associated with prosthetic limb use are common. While a range of skin diagnoses, such as allergic contact dermatitis, epidermal hyperplasia, malignancies, and ulcerations, have been described [4], we found no consistency in the literature regarding how these problems are reported. Accordingly, we do not know the epidemiology of the residual-limb dermatologic issues faced by individuals with lower-limb loss. A recent literature review [5] cited only one study [6] with sufficient rigor to ascertain a prevalence of 16 percent for skin problems on the residual limb. However, the skin problems reported in that study were limited to abscesses and ulcers, a narrow subset of the whole spectrum of dermatologic issues that could affect prosthetic limb use and user satisfaction.

As a first step toward filling this gap in knowledge, we undertook a systematic review of the literature to better define the prevalence and types of skin problems on the residual limb related to prosthetic use. We use this information to propose a classification system that may be of use in future clinical studies.

Abbreviation: MeSH = medical subject headings.

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METHODS

We searched the literature published through 2008 using four databases: MEDLINE, EMBASE, CINAHL, and RECAL. MEDLINE is a biomedical database containing publications since the 1950s. EMBASE is a biomedical and pharmacological database containing publications since 1988. CINAHL is a nursing and allied health database containing publications since 1982. RECAL is an orthotics and prosthetics database containing publications from 1900 to 2007. **Table 1** shows medical subject headings (MeSH) and free text words that we used to search MEDLINE, CINAHL, and EMBASE. MeSH are standardized terms defined by the National Library of Medicine and arranged in a hierarchical structure that allows searching at various levels of specificity. In RECAL, we used the free text words “skin” and “amputation” (MeSH not available). We restricted our search to the English language and humans in MEDLINE and EMBASE and to the English language in CINAHL (option to limit to human research not available).

We reviewed the title and abstract of all publications identified in our literature search. We selected articles if they discussed skin problems in adults (≥ 18 years old) with lower-limb loss (transtibial, transfemoral, or knee disarticulation, but not foot, ankle, or hip disarticulation) who were fitted with a prosthesis. We excluded articles that discussed wound healing immediately postamputation. We removed duplicate articles obtained from different databases.

Our second selection process involved reviewing study research methodology. We selected articles if they included a description of the inclusion and exclusion criteria and the study population, identified the reason for amputation, identified the level of amputation, and reported both the prevalence and types of skin problems on a residual limb associated with prosthetic limb use. We excluded all case studies, case series, reviews, expert opinions, and letters to editors. We also excluded articles published before 1990 or with a sample size of fewer than 40 subjects.

Lastly, we reviewed the reference lists of these articles for publications related to skin problems in individuals with

Table 1.

Medical subject headings, free text words, and combinations used in MEDLINE, CINAHL, and EMBASE literature searches.

No.	MEDLINE	CINAHL	EMBASE
1	amputation/ or disarticulation/	amputation/ or amputation, traumatic/	amputation/ or traumatic amputation/
2	residual limb.mp	above-knee amputation/ or below-knee amputation	limb amputation/ or leg amputation/ or knee amputation
3	amputation stumps/	residual limb.mp or amputation stumps/	above-knee amputation/ or below-knee amputation
4	(amputation or stump or disarticulation).mp	(amputation or stump or disarticulation).mp	residual limb.mp/ or amputation stump/
5	amputees/ or amputee.mp	amputees/ or amputee.mp	(disarticulation or amputation or stump or amputee).mp
6	1 or 2 or 3 or 4 or 5	1 or 2 or 3 or 4 or 5	1 or 2 or 3 or 4 or 5
7	lower extremity/ or leg/ or knee/ or thigh/	lower extremity/ or knee/ or leg/ or thigh/	limb/ or leg/ or knee/ or lower leg/ or thigh/
8	(lower extremity or lower limb or tibia or femur or trans-tibial or trans-femoral or leg* or knee* or thigh*).mp	(lower extremity or lower limb or tibia or femur or trans-tibial or trans-femoral or leg* or knee* or thigh*).mp	femur/ or tibia/ (lower extremity or trans- tibial or trans-femoral or femur* or tibia* or leg* or knee* or thigh*).mp
9	(metatarsal or foot or ankle or hip).mp	(metatarsal or foot or ankle or hip).mp	(metatarsal or foot or ankle or hip).mp
10	(7 or 8) not 9	(7 or 8) not 9	(7 or 8) not 9
11	prosthetic limb.mp	(prosthetic limb or leg prosthesis).mp	(artificial limb or prosthetic limb or leg prosthesis).mp
12	artificial limbs/ or artificial limb.mp	artificial limb.mp or limb prosthesis/	leg prosthesis/ or limb prosthesis/ or limb prosthesis.mp
13	10 or 11 or 12	10 or 11 or 12	10 or 11 or 12
14	exp * skin diseases/ or exp * skin/	exp * skin diseases/ or exp * skin/	exp * skin diseases/ or exp * skin/
15	prosthesis fitting/adverse effect	prosthesis fitting/adverse effect	13 and 14
16	14 or 15	14 or 15	Limit to English and humans
17	6 and 13 and 16	6 and 13 and 16	—
18	Limit to English and humans	Limit to English	—

lower-limb loss (transtibial, transfemoral, or knee disarticulation). Relevant articles published after 1990 underwent the second selection process we mentioned previously.

RESULTS

Our initial search using MeSH and free text words yielded 777 articles: 313 from MEDLINE, 233 from EMBASE, 31 from CINAHL, and 200 from RECAL (Table 2). Our first selection process yielded 71 publications: 50 from MEDLINE, 5 from EMBASE, 3 from CINAHL, and 13 from RECAL (Table 2). We found an additional 19 related articles published after 1990 in the reference lists. We then reviewed the study methodology of the resulting 90 articles and retained 2 publications from MEDLINE and 2 from the reference lists (Table 2).

The 86 articles we excluded included 41 case reports or case series; 16 reviews or expert opinions; 4 letters to editors; 2 duplicated articles; and 7 articles about topics not of interest, including novel treatments for skin problems, quality of life, shear force, or no reported skin problems. We also excluded an additional two articles: one article (with the exception of its abstract) was written in Korean and the other, although referenced in another study, was unpublished. The remaining 14 articles we excluded were clinical studies discussing skin problems in individuals with limb loss. Four studies discussed both upper- and lower-limb amputations [7–10], one of which

was published before 1990 [7]. Ten cross-sectional and cohort studies about lower-limb loss did not meet our selection criteria because of insufficient sample size [11–12], the presence of nonadult participants [13–17], missing selection criteria [14], failure to report the prevalence of skin problems [14,18], or lack of skin problem specification [12,17,19–20].

Table 3 identifies the four publications that met our selection criteria, representing research performed in the Netherlands, Canada, the United States, and Singapore from 1990 to 2008 [6,21–23]. All the studies were cross-sectional and obtained data through either a chart review or a questionnaire delivered by mail or telephone. A physician assessed skin problems in three out of the four studies; the last study was by patient self-report [23]. The most common reasons for amputation were vascular disease, diabetes, and trauma. The most common amputation level was transtibial.

The overall prevalence of skin problems ranged from 15 to 41 percent, with increasing prevalence in the more recent studies. The most commonly reported skin problems ($\geq 20\%$) were wounds (including ulcers), abscesses, and blisters. The articles did not specify the method of skin problem assessment (i.e., physical examination, laboratory data, or biopsy).

DISCUSSION

We found one systematic literature review about skin problems in individuals with lower-limb loss that reviewed the literature published through 2002 [5]. We used similar methodological assessment criteria, including an assessment of the inclusion and exclusion criteria, a description of the study population, and the prevalence rate of skin problems. We added several criteria, including the level of amputation, the reason for amputation, and a description of types of skin problems. These additions allowed us to narrow our focus to lower-limb amputations, better characterize the study populations, and describe the types of skin problems commonly reported in the literature.

The limited number of cohort studies ($n = 4$), none of which met our inclusion criteria, identifies an area for future research. Because of the inherent limitations of a cross-sectional study, including the inability to obtain an incidence of skin problems and to infer causality of factors that may lead to skin problems, we recommend that future studies answer these questions by using more rigorous study designs.

Table 2.

Source and number of publications we identified, included, and excluded.

Source	Publications Identified	Included After First Selection*	Identified in Reference Lists†	Included After Second Selection‡
MEDLINE	313	50	—	2
EMBASE	233	5	—	0
CINAHL	31	3	—	0
RECAL	200	13	—	0
Reference Lists	—	—	19	2
Total	777	71	19	4

*Title and abstracts were reviewed. Publications were included if discussed skin problems in adults (≥ 18 years old) with lower-limb loss (not foot, ankle, or hip) and in English.

†Titles and abstracts (if available) were reviewed for all articles published after 1990. Articles were included if discussed skin problems in adults (≥ 18 years old) with lower-limb loss (not foot, ankle, or hip).

‡Entire article reviewed. Publications were included if they discussed inclusion and exclusion criteria, study population, reason for amputation, level of amputation, skin problems on residual limb related to prosthesis use, and prevalence and types of skin problems.

Table 3.
Qualified studies of reported skin problems.*

Study	Country of Study	Type of Study	n	Study Population	Reason for Amputation (%)	Amputation Level (%)	Assessment of Skin Problems	Overall Prevalence (%)	Types of Skin Problems (%)
Baars et al., 2008 [1]	The Netherlands	Cross-sectional chart review	Subjects (60)	Rehabilitation hospital (1998–2006)	Vascular (63.0) Trauma (10.0) Infection (8.0) DM (8.0) Other (11.0)	Transtibial (83.0) Knee disarticulation (17.0)	Exam by physiatrist	38	Superficial wound (69) Blister (22) Folliculitis (6) Rash (3)
Dudek et al., 2005 [2]	Canada	Cross-sectional chart review	Subjects (745) Residual limbs (828)	Amputee clinic (1997–2003)	PVD/DM (50.0) Trauma (33.0) Other (17.0)	Transtibial (66.4) Transfemoral (19.2) Other (14.4)	Exam by physiatrist	41	Ulcer (27) Irritation (17) Inclusion cyst (15) Callus (11) Verrucous hyperplasia (9) Blister (7) Fungal infection (5) Cellulitis (2) Other (7)
Pezzin et al., 2000 [3]	United States	Cross-sectional telephone interview	Subjects (78)	University-affiliated trauma center (1984–1994)	Trauma (100.0)	Transtibial (51.0) Transfemoral (20.0) Knee disarticulation (17.0) Other (12.0)	Patient self-report	24	Wound or sore (100)
Chan and Tan, 1990 [4]	Singapore	Cross-sectional questionnaire	Subjects (47)	Amputee clinic (1989–1990)	DM (85.1) Malignancy (8.5) Vascular (6.4)	Transtibial (93.6) Symes (4.3) Transfemoral (2.1)	Exam by physiatrist	15	Ulcer (57) Abscess (43)

*All clinical studies that described inclusion and exclusion criteria, study population, reason for amputation, level of amputation, skin problems on residual limb related to prosthesis use, and prevalence and types of skin problems.

1. Baars EC, Dijkstra PU, Geertzen JH. Skin problems of the stump and hand function in lower limb amputees: A historic cohort study. *Prosthet Orthot Int.* 2008; 32(2):179–85. [PMID: 18569886]
DOI:10.1080/03093640802016456
2. Dudek NL, Marks MB, Marshall SC, Chardon JP. Dermatologic conditions associated with use of a lower-extremity prosthesis. *Arch Phys Med Rehabil.* 2005; 86(4):659–63. [PMID: 15827914]
DOI:10.1016/j.apmr.2004.09.003
3. Pezzin LE, Dillingham TR, MacKenzie EJ. Rehabilitation and the long-term outcomes of persons with trauma-related amputations. *Arch Phys Med Rehabil.* 2000; 81(3):291–300. [PMID: 10724073]
DOI:10.1016/S0003-9993(00)90074-1
4. Chan KM, Tan ES. Use of lower limb prosthesis among elderly amputees. *Ann Acad Med Singapore.* 1990;19(6):811–16. [PMID: 2130743]

DM = diabetes mellitus, PVD = peripheral vascular disease.

None of the clinical studies included a definition or standardized method of assessment for skin problems, thus making it difficult for us to describe and categorize the common types of skin problems in individuals with lower-limb loss. In the literature, some studies consider perspiration and hygiene problems as factors leading to skin problems [2], whereas others categorize these precursor conditions as skin problems themselves [11,14,18]. Some studies reported using patch testing and swab testing to clarify the underlying etiology of skin problems [13], whereas others did not report

how the skin problems were assessed and subsequently diagnosed [15,22]. Description of skin problems varied across studies and depended on the person reporting the skin problems (patient vs physician), with more detailed descriptions provided by physicians. The lack of standardization made it difficult for us to accurately compare the prevalence rates of skin problems across studies and to describe the most commonly occurring skin problems. Differing skin problem prevalence rates may also be attributed to the etiology of the amputation or the country of study.

Our study is limited to reviewing the existing literature (1990–2008) about individuals with lower-limb loss. We did not include unpublished studies, those with a sample size of fewer than 40 subjects, or those written in languages other than English. To the best of our knowledge, this study comprehensively reviews the literature that exists on skin problems in individuals with lower-limb loss. In addition to completing a search inquiry in four databases, we also reviewed reference lists to ensure that we did not miss relevant studies.

We recommend that future classification of lower-limb problems on the residual limb be categorized according to either morphology or etiology rather than with generalizations (e.g., “rash” or “wound”). Hygiene problems, odor, and sweating should be considered precursors to skin problems. We propose a classification schema as shown in **Tables 4** and **5**, in which the same skin conditions are included regardless of classification strategy. Standardized definitions of skin problems will allow clinicians and researchers to report the prevalence and types of skin problems on residual limbs with improved external validity and reliability.

CONCLUSIONS

We conclude that the prevalence of skin problems in individuals with lower-limb loss from 1990 to 2008 was 15 to 41 percent; the most commonly reported skin problems were wounds, abscesses, and blisters. The prevalence and types of skin problems reported varied by study and

their respective method of assessment and definition of skin problems. We recommend that future studies use the standard dermatology definitions for skin-problem classification as described in **Tables 4** and **5**. We also recommend a standardized assessment of an individual’s residual limb at regular intervals so that comparisons may be made across studies and the causality of skin problems may be better inferred. Through such studies, we will better understand skin problems in individuals with lower-limb loss and effectively devise prevention and intervention for this significant problem.

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Study concept and design: K. M. Bui, G. J. Raugi, G. E. Reiber.
Acquisition, analysis, and interpretation of data: K. M. Bui.
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Statistical analysis: K. M. Bui.

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Table 4.

Classification of dermatologic problems on residual limbs by morphology.

Problem	Morphology
Hyperplastic or Neoplastic Conditions	Squamous cell carcinoma
	Inclusion cyst/epidermoid cyst
	Foreign body reaction
	Callus
	Verrucous hyperplasia
Disruption of Skin Integrity	Wound dehiscence
	Irritation/abrasion
	Blister/erosion/ulcer
Follicular and Pseudofollicular Inflammation	Folliculitis
	Miliaria rubra
Interfollicular Inflammation	Eczema craquelé
	Dermatophytosis
	Allergic contact dermatitis
Infection	Irritant dermatitis
	Cellulitis

Table 5.

Classification of dermatologic problems on residual limbs by etiology.

Problem	Etiology
Surgical Complications	Wound dehiscence
	Foreign body reaction
	Inclusion cyst/epidermoid cyst
Reaction to Repetitive Injury	Callus
	Irritation/abrasion
Reaction to Occlusion: Noninfectious	Blister/erosion/ulcer
	Squamous cell carcinoma
	Folliculitis
Reaction to Occlusion: Infectious	Miliaria rubra
	Eczema craquelé
	Irritant dermatitis
Reaction to Occlusion: Infectious	Verrucous hyperplasia
	Allergic contact dermatitis
	Cellulitis
Reaction to Occlusion: Infectious	Dermatophytosis
	Folliculitis

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