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Elastomeric liners for people with transtibial amputation: survey of prosthetists' clinical practices

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Abstract

Study design—Cross-sectional survey

Background—A diverse range of elastomeric liner products are available to people with transtibial amputation. However, little information is available about how prosthetists select the product best suited to each patient.

Objectives—To determine how prosthetists obtain information about liners, which features are most relevant to the selection process, and which products are used most for patients with transtibial amputation.

Methods—A custom online survey was developed to solicit information about prosthetists' liner selection practices. Prosthetists with experience managing transtibial patients were recruited via advertisements posted in magazines, at conferences, and on a listserv. Responses were analyzed to characterize prosthetists' liner selection practices.

Results—Data from 106 experienced prosthetists (mean age 44.4yrs, mean experience 15.7yrs) were included. Most prosthetists (94%) obtained liner information from manufacturer representatives, websites, or literature. On average, respondents factored 9 different liner characteristics into their selection processes. Prosthetists reported experience with 16 unique liner products with their transtibial patients, but routinely used fewer than 3.

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Disclosure

The authors declare no conflict of interest.

Author Contributions

Study concept and design: Brian Hafner, John Cagle, Katheryn Allyn, Joan Sanders

Acquisition of data: Brian Hafner, John Cagle, Katheryn Allyn

Analysis and interpretation of data: Brian Hafner

Drafting of manuscript: Brian Hafner

Critical revision of manuscript for important intellectual content: John Cagle, Katheryn Allyn, Joan Sanders

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Conclusions—Although many different prosthetic liners are available, prosthetists regularly use only a few select liner products. Tools or strategies to objectively compare prosthetic liners across manufacturers are likely needed to facilitate more diverse prescription practices.

Background

The quality of socket fit is commonly acknowledged by both patients and prosthetists as the most important aspect of a prosthesis.^{1–3} The prosthetic liner, which acts as an interface between the rigid socket and the delicate tissues of the residual limb, is a primary contributor to socket fit. The prosthetic liner generally serves two key functions – to protect the residual limb, and to couple the limb to the prosthesis.^{2,4,5} The liner therefore plays a key role in achieving a well-fitting, comfortable, and functional prosthetic limb.²

Selecting a liner for an individual patient requires careful consideration of the patient's physical presentation, their functional status, and their personal goals. A prosthetist must also consider the liner's design, features, and performance in order to appropriately match it to the patient's needs. Contemporary prosthetic liners are often made of elastomeric materials (i.e., copolymer, polyurethane, silicone, thermoplastic elastomer), but vary in their chemical and physical composition. As such, liners exhibit a range of mechanical properties (e.g., coefficient of friction, compressive stiffness, shear stiffness, and tensile stiffness).^{5,6} These properties directly affect the liner's ability to suspend the prosthesis on the limb, resist shear stresses that can lead to skin breakdown, accommodate limb volume fluctuations, limit pistoning, and protect bony prominences.^{5–7} The challenge for the prosthetist is in choosing a liner product from the many available options.

At present, there are dozens of commercial elastomeric liner products available for patients with transtibial amputation. While the availability of so many liners allows practitioners to choose the liner most appropriate for each individual patient, the great diversity of products may also challenge practitioners to stay up-to-date on available options. Regrettably, there is limited scientific evidence available to direct selection of liners for prosthetic patients. In absence of empirical evidence, it has been suggested that prosthetists' liner selection practices are instead guided by product literature, peer recommendations, experience, or intuition.⁸ However, research is needed to confirm this assumption or determine which other factors contribute to prosthetists' selection processes. Knowledge of prosthetists' selection practices may also help to inform development of liners with desirable characteristics or creation of resources (i.e., tools or educational materials) to assist practitioners with matching liners with specific patients.

The purpose of this study was to determine how prosthetists gained information about elastomeric liners, what liner characteristics factored into their selection decisions, and which liners were most often selected for their patients with transtibial amputation. We hypothesized that prosthetists receive information about elastomeric liners primarily from prosthetic manufacturers.⁸ We also expected that prosthetists select liners based on their ability to fulfil the fundamental goals of a liner (i.e., protect the limb and suspend the prosthesis).² Lastly, we expected that prosthetists would routinely use a small number of liners with which they have experience.⁸ To address these hypotheses, we developed and

administered an online survey to prosthetists in North America. Results were used to characterize prosthetists' liner prescription practices and to identify opportunities for improving how prosthetic liners are selected for individual patients.

Methods

Participants

Prosthetists with experience providing care to lower limb prosthetic patients were recruited to participate in the study. Inclusion criteria were 21 years of age or older; eligible to provide prosthetic services in the U.S. or Canada; at least 1 year experience providing prosthetic services of persons with lower limb loss; and ability to read, write, and understand English. No exclusion criteria were applied. Candidate participants were identified through print advertisements in clinical magazines (e.g., O&P Edge), flyers posted at professional meetings (e.g., American Academy of Orthotists and Prosthetists Annual Meeting), and postings to the orthotic and prosthetic listserv (i.e., OANDP-L).

Survey Design

An online, self-report survey (Appendix 1) was developed to solicit information about prosthetists' liner selection practices. Examples of specific elastomeric liner products were drawn from prosthetic distributors (e.g., SPS, Alpharetta, GA; Cascade, Chico, CA) and manufacturer (e.g., Otto Bock, Austin, TX; Össur, Reykjavik, Iceland) websites and catalogs, in consultation with clinical prosthetists. Questions were grouped according to the following categories: sources of liner product information (2 questions), characteristics of importance in liner selection (1 question), and use of existing liner products (9 questions). The survey also included demographic questions (e.g., sex, age, ethnicity, race) and questions related to professional experience (e.g., clinical education, certification, experience). Response options (e.g., multiple-choice, short answer) varied by question. Questions were pilot-tested with three prosthetists and feedback was used to revise questions, as needed. The survey was administered using open-source survey software (Catalyst WebQ) hosted at the University of Washington (Seattle, WA).

Survey Administration

Study postings directed interested prosthetists to a website to determine their eligibility. Respondents self-screened by answering a series of questions about the study inclusion criteria (e.g., "Are you eligible to provide prosthetic services in the U.S. or Canada?"). Respondents that met the inclusion criteria were directed to the survey. Upon conclusion of the survey, respondents were allowed to enter a drawing for one of ten \$50 gift cards. No identifiable information was collected, unless respondents elected to enter the drawing. The survey remained available for 2 months. All study procedures were reviewed and determined to qualify for exempt status by a University of Washington institutional review board.

Analysis

Survey records were exported from WebQ to Microsoft Excel (Microsoft, Redmond WA) for data visualization and analysis. Survey results were screened for missing data and/or potentially invalid responses (e.g., respondents selected the same answer to all questions).

Frequencies and percentages were calculated for survey questions with nominal and ordinal responses (e.g., sex and level of education); means and standard deviations were calculated for questions with ratio responses (e.g., age and time in clinical practice). Responses regarding use of specific liner products were used to bin the product as “routinely used” (i.e., respondent reported using the product ‘always’ or ‘often’) or “not routinely used” (i.e., respondent reported using the product ‘sometimes,’ ‘rarely,’ or ‘never’) to facilitate presentation of data. Responses to optional, open-ended questions were reviewed and summarized.

Results

Respondent characteristics

One hundred thirteen people responded to the survey. Seven respondents were removed from the dataset due to invalid responses. Respondents in the final dataset (n=106, Table 1) were mostly male (78%), non-Hispanic white (87%), and United States residents (89%). On average, respondents were mid-career and experienced in providing prosthetic care to people with limb loss (i.e., mean age = 44.4 years, 15.8 years in prosthetics practice).

Sources of liner product information

Respondents indicated that they received information about liners from a variety of sources (Figure 1). The large majority of respondents (94%) reported that they obtained information from manufacturers (i.e., representatives, websites, or literature). Fewer reported receiving information at conferences or meetings (75%) from clinical magazines (65%) or from scientific journals (33%). A number of respondents noted (via their open-ended comments) that they also obtained information from other prosthetists (18% of respondents) and patients (5% of respondents).

Characteristics of importance in liner selection

Prosthetists reported that a number of liner characteristics contributed to their selection process (Figure 2). On average, respondents indicated that 9 of the 22 liner characteristics included in the survey were considered when selecting a liner for their prosthetic patients. The most commonly endorsed properties included durability (91%), comfort (87%) and suspension features (78%); the least common were appearance (8%), temperature control (7%), and visual features (2%). Prosthetists noted (via open-ended comments) other characteristics that were not listed in the survey, including ease of donning/doffing (n=6), range of knee motion (n=2), and available sizes (n=1). Multiple prosthetists (n=8) noted that their priority characteristics would be dependent on the patient (e.g., limb shape, skin quality, activity level, medical history).

Use of existing liner products

On average, prosthetists reported having used 16 of the 71 liners listed on the survey with their patients, but routinely (i.e., ‘always’ or ‘often’) used only 2–3 (mean=2.6, SD=2.0) unique liner products (Table 2). A small portion of respondents (11%) indicated they ‘always’ used a single liner product with all their patients. Each of the 71 liner products included in the survey was used by at least two prosthetists, but no single product was used

by all prosthetists. Liner products by Össur, WillowWood, ALPS, Otto Bock, and medi were among those most routinely used by prosthetists in the study (Table 3). Routinely-used products were manufactured from a variety of materials, including silicone (n=13), thermoplastic elastomer (n=8), and urethane (n=3).

Discussion

To our knowledge, this is the first study to evaluate prosthetists' prosthetic liner prescription practices. We used an online survey to solicit information from experienced prosthetists about the elastomeric liners they provided to their patients with transtibial amputation. Similar surveys have been used to assess other aspects of prosthetists' professional practices, including utilization of evidence from state-of-the-science conferences,⁹ perceived barriers and facilitators to evidence-based practice,¹⁰ and use of outcome measures in clinical practice.¹¹ Here, the survey was used to identify resources prosthetists used to obtain information about elastomeric liners, characteristics of importance in the clinical selection process, and specific liner products used by prosthetists.

Sources of liner product information

As expected,⁸ prosthetists predominantly obtained information about liner products from manufacturers. Factors that contribute to the reported preference for manufacturer-provided information likely include both the accessibility and timeliness of information obtained in this manner. Despite widely acknowledged barriers to research literature access in O&P,^{12–14} Andrysek et al. reported that most prosthetists have access to journal articles, conferences, and clinical magazines.¹⁰ However, fewer than 50% reported using said resources to obtain clinical information. They were instead more likely to consult with peers or search the internet for answers to clinical questions. Manufacturer-provided liner information is generally free and readily accessible on the internet, and is likely preferred for its ease of access. Similarly, manufacturer-provided information may be more up-to-date than that from other sources. More than 50% of prosthetists acknowledged that a key reason empirical (i.e., research) evidence is not consulted is that it is generally out-of-date.¹⁰ Given that new liners are released regularly, obtaining timely information about these products from sources other than manufacturers may be challenging. Lastly, it is possible that prosthetists rely on manufacturer information in absence of empirical evidence. A relative dearth of evidence pertaining to prosthetic liners has been noted,⁸ and may be a reason for prosthetists' limited use of information from peer-reviewed resources in this study. However, if prosthetists are to engage in evidence-based practices in the future, efforts to develop and disseminate research evidence related to prosthetic liners will be needed.¹²

Characteristics of importance in liner selection

Prosthetists in this study acknowledged that they considered an array of characteristics when selecting a liner for their patients with transtibial amputation. That so many different criteria are considered reinforces the critical importance of a good limb-socket interface,^{1–3} and the clinical challenge in matching each patient with an optimal prosthetic liner. As hypothesized, characteristics most commonly considered pertained to a liner's primary functions, protection of the limb and suspension of the prosthesis.^{2,4,5} Features like comfort,

thickness, and cushion were among the top five most endorsed considerations. Suspension was the third-most endorsed consideration, indicating that it too was a priority. The importance of these characteristics in the selection process is not surprising, as both comfort and suspension are believed to be advantages to elastomeric liners, when compared with other types of interfaces.¹⁵ Cost is increasingly a concern in the provision of health care interventions, like prosthetic liners.⁸ Interestingly, cost of the liner was only considered by about half the sample in the selection process. The patient's cost was considered by far fewer of the prosthetists (16%), likely due to the fixed rate of reimbursement for elastomeric liners under U.S. Center for Medicare and Medicaid Services guidelines.¹⁶

Use of existing liner products

Despite the availability of a large number and variety of elastomeric liners for patients with transtibial amputation, prosthetists generally used relatively few products with their patients. This confirms previous assumptions that prosthetists often elect to use a few liners with which they have experience and success with patients.⁸ Products routinely used were also sourced from just 4 of the 12 liner manufacturers with products included in the survey (i.e., Ossur, WillowWood, ALPS, and Ottobock). The limited diversity of liner selection observed in this study may be due to a variety of factors, including familiarity with products that work well, reluctance to try new products, perceived similarity among available liner products, or an absence of empirical evidence to promote a change in customary liners. As prosthetic liners are not generally interchangeable and changing liners would require fabrication of a new socket, prosthetists may deem the risk to try a new product too high. Services provided by the manufacturer (e.g., discounts, education, samples, rapid shipping, or overall customer service) may also influence selection and encourage prosthetists to more often use specific products.

Directions for future work

Results of this study can be used to direct future research and educational efforts. For example, the limited diversity of liners used by respondents in the study may indicate that prosthetists do not have sufficient information about liners, other than those few with which they have experience. To consider new liners, practitioners may need tools that allow them to easily compare and contrast liner properties. For example, the Prosthetic Liner Assistant (PLA), an interactive database of elastomeric liner products, was developed to allow practitioners to compare and contrast commercial liners by material (i.e., copolymer, polyurethane, silicone, thermoplastic elastomer), thickness (i.e., fixed-thickness, tapered, or anatomic), or mechanical properties (i.e., compressive resistance, shear resistance, stretch resistance, adherence, volume accommodation, thermal conductivity, and cost).¹⁷ Results of this study may inform development of new tests to include in the PLA, so that it includes additional characteristics of importance to prosthetists (e.g., liner durability).

Study results could also be used to guide development of educational resources for students and practicing clinicians. For example, continuing educational courses that explain how specific liner material properties^{6,18–20} affect users' limb health outcomes^{21,22} may encourage practitioners to consider liners that exhibit desirable characteristics. Resources (e.g., clinical algorithms) could be developed from these efforts to help practitioners

determine whether elastomeric liners are appropriate for the patient, and which products would best serve specific patients. Development and application of evidence-based clinical algorithms or guidelines would also encourage professional practices and support justification of selected liners.

Results of this study may also guide new research and development efforts. Development of new liner materials has been noted as a priority by prosthetic researchers.²³ The priority of liner characteristics identified by respondents in this study may aid in development of liners that target features of clinical need. For example, durability was noted as an important liner feature among more than 90% of all prosthetists in this study. Concerns of elastomeric liner durability are also acknowledged in the scientific literature. Efforts to make liners more durable are challenging, as liners with increased durability generally transmit higher shear forces and increase risk of skin breakdown.²⁴ Thus, novel approaches to developing liners that are both soft and durable should be considered a priority. Development of liners with improved durability could improve patient satisfaction and reduce health care costs.

Study limitations

The number of participants in this study (n=106) was relatively small compared to the overall population of prosthetists in the U.S. and Canada (estimated at 5800 and 200, respectively).^{25,26} However, prosthetists included in the study sample (Table 1) reflected the current diversity of prosthetists in the field by sex, age, ethnic and racial status, education level, and years of clinical experience.²⁷ Study participants were recruited through advertisements posted in clinical magazines, at conferences, or on the O&P listserv. Thus, the sample may be biased toward clinicians with a tendency to seek knowledge about clinical interventions through publications, meetings, or peer communications. Prosthetists that do not utilize these resources, and instead rely primarily on experience and/or intuition when selecting interventions for their patients may not be well reflected in the study sample.

We also restricted participation in the study to prosthetists in North America, and most of the respondents (89%) were from the United States. Thus, the practice patterns described by our results may not reflect those of prosthetists in other areas of the world. Differences in health care and reimbursement systems present in the U.S. (e.g., fixed-cost reimbursement for prosthetic liners) may affect selection practices. Prosthetists who practice in places with different financial, legal, or medical policies may select liners based on other criteria. Evaluation of practices in these areas is needed to confirm similarities or differences with the results reported here.

Another limitation to this study is the method used to collect data about prosthetists' liner practices. The survey used in this study was developed by the investigators to address the proposed hypotheses. We pilot tested the survey and revised questions based on feedback from several clinical prosthetists prior to large scale administration. However, as the goal of the survey was to solicit general information about practice patterns (and not to derive a score like in a traditional health outcomes survey), we elected not to subject the survey questions to more formal psychometric testing methods. This approach is common in surveys of professional practice patterns.^{27,28}

Conclusions

The goal of this study was to further our understanding of prosthetists' liner selection practices, specifically how prosthetists learn about and choose liners for individual patients. Results indicate that manufacturers are the primary source of information about both new and existing prosthetic liner products. When choosing liners, prosthetists consider a range of characteristics related to both the liner and patient. Fundamental liner properties like durability, comfort, and suspension are often a priority. Results also show that prosthetists use only a few different prosthetic liner products for their patients with transtibial amputation, despite the commercial availability of more than 70 unique products. Reasons for prosthetists' liner restricted practices are unclear, but may be due to a scarcity of objective and comparable information about available liner products. Objective tools or resources that allow practitioners to compare and contrast desirable liner characteristics may help to facilitate greater variety in product selection and ability to match individual patients with the liner product best suited to their needs.

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List of Abbreviations

O&P	orthotics and prosthetics
SD	standard deviation
U.S	United States

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Appendix 1. Screenshots of the elastomeric liner survey administered to study respondents

Elastomeric Liner Survey

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Where do you typically find information about existing elastomeric liner products? (please check all that apply)

- ☐ Manufacturer representatives
- ☐ Manufacturer websites
- ☐ Manufacturer literature
- ☐ Conferences / meetings (e.g., AAOP, AOPA National meetings)
- ☐ Clinical magazines (e.g., O&P Edge, O&P Almanac)
- ☐ Scientific journals (e.g., Journal of Prosthetics & Orthotics, Prosthetics & Orthotics International)
- ☐ Other (please give examples):

Where do you typically find information about new elastomeric liner products? (please check all that apply)

- ☐ Manufacturer representatives
- ☐ Manufacturer websites
- ☐ Manufacturer literature
- ☐ Conferences / meetings (e.g., AAOP, AOPA National meetings)
- ☐ Clinical magazines (e.g., O&P Edge, O&P Almanac)
- ☐ Scientific journals (e.g., Journal of Prosthetics & Orthotics, Prosthetics & Orthotics International)
- ☐ Other (please give examples):

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Which of the following characteristics do you consider most often when selecting elastomeric liners for your transtibial prosthetic patients? (please check all that apply)

- ☐ Comfort
- ☐ Durability
- ☐ Appearance
- ☐ Cost to you
- ☐ Cost to your patient
- ☐ Temperature control
- ☐ Moisture control
- ☐ Odor control
- ☐ Maintenance / hygiene
- ☐ Pressure distribution / flow
- ☐ Adhesion to skin
- ☐ Shear / friction resistance
- ☐ Cushion / shock absorption
- ☐ Radial / circumferential elasticity
- ☐ Axial elongation / pistoning
- ☐ Fabric features (e.g., abrasion resistant panels, waves)
- ☐ Physical features (e.g., umbrella, matrix)
- ☐ Visual features (e.g., logos, transparency)
- ☐ Thickness features (e.g., tapers, region-specific thickness)
- ☐ Shape features (e.g., heat-shaping, pre-flexion)
- ☐ Gel features / additives (e.g., antibacterial lotion, mineral oil)
- ☐ Suspension features (e.g., pins, seals)

Please use the space below to comment on (or list) any other characteristics that factor into your liner selection process:

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Please indicate how often you have delivered the following WillowWood prosthetic liner products to transtibial prosthetic patients in the last 12 months.

	Never	Rarely	Sometimes	Often	Always
WillowWood Alpha Silicone (Select Fabric)	☐	☐	☐	☐	☐
WillowWood Classic (Max Fabric)	☐	☐	☐	☐	☐
WillowWood Classic (Original Fabric)	☐	☐	☐	☐	☐
WillowWood Classic (Spirit Fabric)	☐	☐	☐	☐	☐
WillowWood Classic (Select Fabric)	☐	☐	☐	☐	☐
WillowWood Hybrid (Select Fabric)	☐	☐	☐	☐	☐
Other WillowWood liner not listed	☐	☐	☐	☐	☐

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Please indicate how often you have delivered the following Silipos prosthetic liner products to transtibial prosthetic patients in the last 12 months.

	Never	Rarely	Sometimes	Often	Always
Silipos Single Socket Gel	☐	☐	☐	☐	☐
Silipos Double Socket Gel	☐	☐	☐	☐	☐
Silipos Ultra Cushion Gel	☐	☐	☐	☐	☐
Silipos SiloLiner	☐	☐	☐	☐	☐
Silipos Duragel	☐	☐	☐	☐	☐
Silipos Low Activity	☐	☐	☐	☐	☐
Other Silipos liner not listed	☐	☐	☐	☐	☐

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Please indicate how often you have delivered the following Otto Bock prosthetic liner products to transtibial prosthetic patients in the last 12 months.

	Never	Rarely	Sometimes	Often	Always
Otto Bock 3D PUR	☐	☐	☐	☐	☐
Otto Bock Balance TPE	☐	☐	☐	☐	☐
Otto Bock Custom	☐	☐	☐	☐	☐
Otto Bock Copolymer Liner	☐	☐	☐	☐	☐
Otto Bock Profile	☐	☐	☐	☐	☐
Otto Bock SiliconGel	☐	☐	☐	☐	☐
Otto Bock SiliconGel w/antibacterial	☐	☐	☐	☐	☐
Otto Bock Simplicity	☐	☐	☐	☐	☐
Otto Bock Standard-Pro w/o fabric	☐	☐	☐	☐	☐
Otto Bock Standard-Pro w/ fabric	☐	☐	☐	☐	☐
Other Otto Bock liner not listed	☐	☐	☐	☐	☐

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Elastomeric Liner Survey

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Please indicate how often you have delivered the following Össur prosthetic liner products to transtibial prosthetic patients in the last 12 months.

	Never	Rarely	Sometimes	Often	Always
Össur Iceross Activa	☐	☐	☐	☐	☐
Össur Iceross Comfort	☐	☐	☐	☐	☐
Össur Iceross Comfort Cushion	☐	☐	☐	☐	☐
Össur Iceross Dermo	☐	☐	☐	☐	☐
Össur Iceross Dermo Cushion	☐	☐	☐	☐	☐
Össur Iceross Dermo Seal-In	☐	☐	☐	☐	☐
Össur Iceross Original	☐	☐	☐	☐	☐
Össur Iceross Seal-In V	☐	☐	☐	☐	☐
Össur Iceross Seal-In XS	☐	☐	☐	☐	☐
Össur Iceross Sport	☐	☐	☐	☐	☐
Össur Iceross Synergy	☐	☐	☐	☐	☐
Össur Iceross Synergy Cushion	☐	☐	☐	☐	☐
Other Össur liner not listed	☐	☐	☐	☐	☐

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Elastomeric Liner Survey

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Please indicate how often you have delivered the following medi prosthetic liner products to transtibial prosthetic patients in the last 12 months.

	Never	Rarely	Sometimes	Often	Always
medi Relax	☐	☐	☐	☐	☐
medi Sensitive	☐	☐	☐	☐	☐
medi Protect Care	☐	☐	☐	☐	☐
medi AKOS	☐	☐	☐	☐	☐
Other medi liner not listed	☐	☐	☐	☐	☐

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Elastomeric Liner Survey

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Please indicate how often you have delivered the following ESP prosthetic liner products to transtibial prosthetic patients in the last 12 months.

	Never	Rarely	Sometimes	Often	Always
ESP Aegis SoFlex	☐	☐	☐	☐	☐
ESP Aegis Streamline w/ fabric	☐	☐	☐	☐	☐
ESP Aegis Streamline w/o fabric	☐	☐	☐	☐	☐
ESP Aegis Ultimate	☐	☐	☐	☐	☐
ESP Seal-Pro w/ fabric	☐	☐	☐	☐	☐
ESP Seal-Pro w/o fabric	☐	☐	☐	☐	☐
Other ESP liner not listed	☐	☐	☐	☐	☐

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Elastomeric Liner Survey

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Please indicate how often you have delivered the following Euro International prosthetic liner products to transtibial prosthetic patients in the last 12 months.

	Never	Rarely	Sometimes	Often	Always
Euro International Active Care	☐	☐	☐	☐	☐
Euro International Clear	☐	☐	☐	☐	☐
Euro International Clear (Matrix 10)	☐	☐	☐	☐	☐
Euro International ClearTex	☐	☐	☐	☐	☐
Euro International ContextGel	☐	☐	☐	☐	☐
Euro International First Class	☐	☐	☐	☐	☐
Euro International First Class Plus	☐	☐	☐	☐	☐
Euro International Primo	☐	☐	☐	☐	☐
Euro International Skin Care	☐	☐	☐	☐	☐
Euro International Skin Care Plus	☐	☐	☐	☐	☐
Euro International Two Color	☐	☐	☐	☐	☐
Other Euro International liner not listed	☐	☐	☐	☐	☐

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Elastomeric Liner Survey

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Please indicate how often you have delivered the following ALPS prosthetic liner products to transtibial prosthetic patients in the last 12 months.

	Never	Rarely	Sometimes	Often	Always
ALPS Easyliner	☐	☐	☐	☐	☐
ALPS Extreme Gel	☐	☐	☐	☐	☐
ALPS EZ Flex	☐	☐	☐	☐	☐
ALPS General Purpose	☐	☐	☐	☐	☐
ALPS Liberty Liner II	☐	☐	☐	☐	☐
ALPS Proximal Seal	☐	☐	☐	☐	☐
ALPS Super Stretch	☐	☐	☐	☐	☐
Other ALPS liner not listed	☐	☐	☐	☐	☐

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Elastomeric Liner Survey

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Please indicate how often you have delivered the following g@r prosthetic liner products to transtibial prosthetic patients in the last 12 months.

	Never	Rarely	Sometimes	Often	Always
Fillauer Absolute	☐	☐	☐	☐	☐
Proteor Stepline Plus	☐	☐	☐	☐	☐
R&B Medical Allegro	☐	☐	☐	☐	☐
R&B Medical Rythm	☐	☐	☐	☐	☐
R&B Medical Sonata	☐	☐	☐	☐	☐
ST&G Forte	☐	☐	☐	☐	☐
ST&G Magliner - Hydro	☐	☐	☐	☐	☐
ST&G Magliner - Premier	☐	☐	☐	☐	☐
ST&G Par@sil	☐	☐	☐	☐	☐
Other liner by any company not listed	☐	☐	☐	☐	☐

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Elastomeric Liner Survey

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Please indicate your sex:

- ☐ Male
☐ Female

Please indicate your age (in years):

Please indicate your ethnicity:

- ☐ Hispanic or Latino
☐ Not Hispanic or Latino

Please indicate your race (please check all that apply):

- ☐ White
☐ Black or African-American
☐ American Indian or Alaskan Native
☐ Asian
☐ Native Hawaiian or other Pacific Islander

Please indicate any degrees and/or certificates you have earned (please check all that apply):

- ☐ Prosthetics certificate
☐ Bachelors (e.g., BPO)
☐ Masters (e.g., MSPO/MPO)
☐ Doctorate (e.g., PhD)
☐ Other:

Please indicate your current clinical certification (please check all that apply):

- ☐ Certified prosthetist (CP)
☐ Certified prosthetist-orthotist (CPO)
☐ Other:

Please indicate any non-prosthetics clinical experience you may have:

- ☐ Physical therapy / physiotherapy
☐ Occupational therapy
☐ Nursing
☐ Physical therapy assistant
☐ Exercise physiology
☐ Physical training
☐ Other:

Please indicate how long you have been in clinical practice (in years):

Enter a number (without commas).

Please indicate how long you have been practicing as a prosthetist (in years):

Enter a number (without commas).

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Clinical Relevance

Knowledge of prosthetists' prosthetic liner selection practices may guide development of evidence-based resources or tools to facilitate matching patients with appropriate liners. Results of this study may also inform researchers and manufacturers about desirable liner characteristics and direct development of novel liner products to address prosthetists' clinical needs.

Figure 1.
Sources of prosthetic liner information. Prosthetists identified where they obtained information about existing (black) and new (grey) prosthetic liners.

Figure 2.

Characteristics that affect prosthetists' selection of liner products. Characteristics are presented in order of those most commonly endorsed by surveyed prosthetists.

Table 1

Demographic characteristics for study participants (n=106)

Characteristic	Number (N)	Percent (%)
Country of residence		
United States	94	89%
Canada	3	3%
Gender		
Male	83	78%
Female	23	22%
Ethnicity		
Hispanic or Latino	0	0%
Not Hispanic or Latino	102	96%
Race		
White	92	87%
Black or African-American	0	0%
American Indian or Alaskan Native	2	2%
Asian	4	4%
Native Hawaiian or other Pacific Islander	2	2%
Education		
Certificate	74	70%
Bachelors	55	52%
Masters	12	11%
Doctorate	1	1%
Clinical Certification		
CP	45	42%
CPO	58	55%
Other	9	8%
Related Experience		
Physical therapy/physiotherapy	4	4%
Occupational therapy	2	2%
Nursing	2	2%
Physical therapy assistant	6	6%
Exercise physiology	2	2%
Physical training	3	3%
Other	8	8%
Characteristic	Mean	SD
Age (years)	44.4	12.5
Time in clinical practice (years)	17.8	12.8
Time as prosthetist (years)	15.7	12.1

Table 2

Elastomeric liners most often used by prosthetists for people with transtibial amputation. Liners are ranked by the number of respondents who indicated they used the liner regularly (i.e., ‘always,’ ‘often,’ or ‘sometimes’) in clinical practice

Reported Use of Specific Liner Products	Percent of Respondents	Mean (and SD) Number of Liner Products Used at the Stated Frequency
“Always” Used Specific Products	12%	1.1 (0.5)
“Often” Used Specific Products	87%	2.8 (1.9)
“Sometimes” Used Specific Products	96%	6.3 (5.5)
“Rarely” Used Specific Products	91%	8.2 (6.3)
Used Specific Products at Any Frequency	100%	16.0 (10.5)

Table 3

Mean number of liner products used by prosthetists by frequency of use. (Note, means and SDs are based on only those respondents who reported using specific liners at each frequency.)

Rank	Prosthetic Liner Product	Percent of Sample Reporting Routine Use
1	Össur Iceross Comfort	26%
2	WillowWood Classic (Original Fabric)	23%
3	WillowWood Hybrid (Select Fabric)	22%
4	Össur Iceross Dermo	21%
5	Össur Iceross Dermo Cushion	15%
6	Össur Iceross Dermo Seal-In	12%
7	Össur Iceross Comfort Cushion	10%
8	WillowWood Alpha Silicone (Select Fabric)	10%
9	WillowWood Classic (Max Fabric)	9%
10	Össur Iceross Seal-In V	8%
11	Össur Iceross Seal-In X5	8%
12	ALPS General Purpose	7%
13	Otto Bock Custom	7%
14	WillowWood Classic (Spirit Fabric)	7%
15	WillowWood Classic (Select Fabric)	7%
16	ALPS Easyliner	6%
17	ALPS Extreme Gel	5%
18	Otto Bock 3D PUR	4%
19	Össur Iceross Original	4%
20	Össur Iceross Sport	4%
21	Otto Bock SiliconGel (w/antibacterial)	3%
22	medi Relax	3%
23	Össur Iceross Synergy Cushion	2%
24	Otto Bock Profile	2%
25	Otto Bock SiliconGel	2%