The Open Journal of Occupational Therapy

Volume 11
Issue 4 *Fall 2023*

Article 3

October 2023

Thermoplastic Material Selection and Barriers to Custom Orthotic Fabrication: A Survey of Occupational and Physical Therapists

Priya Bakshi
Indiana State University - USA, priya.bakshi@indstate.edu

Daisy Castillo
Indiana State University - USA, dcastillo5@sycamores.indstate.edu

Heidi Mitchener
Indiana State University - USA, hmitchener1@sycamores.indstate.edu

Zoee Lagerhausen
Indiana State University - USA, zlagaerhausen@sycamores.indstate.edu

Lauren Paisley
Indiana State University - USA, lpaisley@sycamores.indstate.edu

See next page for additional authors

Recommended Citation

Bakshi, P., Castillo, D., Mitchener, H., Lagerhausen, Z., Paisley, L., Quinlivan, A., & Andreae, B. (2023). Thermoplastic Material Selection and Barriers to Custom Orthotic Fabrication: A Survey of Occupational and Physical Therapists. *The Open Journal of Occupational Therapy, 11*(4), 1-11. https://doi.org/10.15453/2168-6408.2143

Thermoplastic Material Selection and Barriers to Custom Orthotic Fabrication: A Survey of Occupational and Physical Therapists

Abstract

Background: There is limited literature regarding therapists' selection of thermoplastic material since the 1990s and less is known about the challenges of custom orthotic fabrication.

Methods: A cross-sectional survey was designed and distributed to members of the American Society of Hand Therapists in August 2021. The survey included closed-ended questions with option for free-text comments. Descriptive statistics and content analysis was used to analyze categorical data and free-text comments, respectively.

Results: The responses of 333 therapists were included in the study. Drapability, thickness, and rigidity were the main properties the therapists considered when selecting thermoplastic material (82.9%; 75.7% and 64.9%, respectively). The free-text analysis revealed thermoplastic material selection to be contextual. Occupation of client, activity level, size of body part, climate, purpose of orthoses (mobilize or immobilize), and comorbidities were factors considered when selecting material. Barriers to custom orthotic fabrication were experienced by 79.9% of the therapists. Barriers related to insurance were experienced the most (46.2%) followed by client factors, (27.9%) and administrative factors (18.3%). Limited reimbursement, high patient cost, lack of materials, and time and client compliance were the cited challenges.

Conclusions: Thermoplastic material selection is contextual. Therapists report custom orthotic fabrication to be challenging in the current health care environment.

Comments

The authors declare that they have no competing financial, professional, or personal interest that might have influenced the performance or presentation of the work described in this manuscript.

Keywords

thermoplastic materials, custom orthotic fabrication, hand therapy

Cover Page Footnote

Acknowledgments: Dr. Steven McCaw for his assistance with statistical analysis.

Complete Author List

Priya Bakshi, Daisy Castillo, Heidi Mitchener, Zoee Lagerhausen, Lauren Paisley, Amanda Quinlivan, and Brandi Andreae

Credentials Display

Priya Bakshi, OTD, OTR, CHT; Daisy Castillo, OTS; Heidi Mitchener, OTS; Zoee Lagerhausen, OTS; Lauren Paisley, OTS; Amanda Quinlivan, OTS; Brandi Andreae, OTD, MS, OTR

DOI: 10.15453/2168-6408.2143

Occupational and physical therapists in hand therapy practice use custom and prefabricated orthoses on a daily basis for the rehabilitation of their clients (Keller et al., 2021). Major advancements in custom orthotic fabrication materials occurred with the arrival of low-temperature thermoplastics using polycaprolactones in the 1970s (Fess, 2002). Contemporary thermoplastic materials continue to evolve and are rubber- or plastic-based with specialized blends of either polyisoprenes or polycaprolactones. Additive fillers, elastomers, and resins impact the materials' stiffness, memory, moldability, and durability (Breger-Lee & Buford, 1992). The higher the plastic content of a material, the greater the conformability and drape they have, whereas the higher the rubber content of a material, the more resistance it offers to stretch (Fess et al., 2005). Thickness, perforations, colors, and coating provide additional variations to address individual client needs and circumstances.

The numerous options in thermoplastic materials can make determining the right material for a client challenging for entry-level therapists and therapists new to hand therapy practice. Lee (1995) reported there were special needs in orthosis fabrication, including the knowledge and use of properties of various materials, that should compel therapists to use optimal materials for a particular task. In a 2002 position statement on the use of orthotics in hand therapy, the American Society of Hand Therapists (ASHT) considered the "criteria for optimum material selection" as a Level II skill in a progressive hierarchy of three levels of skills for the safe and effective use of orthoses in hand therapy (ASHT, 2002, p. 2).

Literature provides some insight into therapists' selection of thermoplastic material. Hand therapists surveyed at the annual ASHT meeting in 1991 revealed the properties of conformity, flexibility, price, and thickness most influential in material selection (Lee, 1995). A comparative study by Shimeld et al. (1984) assessed the performance of six different thermoplastic materials (aquaplast, orthoplast, polyform, kay-splint, san-splint, san splint XR) from therapists', students', and patients' perspectives and found that there were significant differences in the time required for therapists to fabricate the orthosis based on the material. The behaviors therapists found desirable in a material were: (a) cuts easily when heated, (b) stays workable for a time sufficient to fabricate the orthosis, (c) becomes soft enough when activated to conform to small contours but not too soft that it became stretchy, (d) spot heats easily without becoming too stretchy, and (e) finished orthosis retains its fit after cooling. The authors reported no preference among the materials from a patient's perspective. A survey to determine the level of satisfaction of 72 recipients of a custom fabricated orthosis found that the top three characteristics determining client satisfaction were comfort, effectiveness, and ease of application of the custom orthosis (Joseph et al., 2018). Thermoplastic materials selection, therefore, lies more in the therapist's purview, with the final product aimed to be comfortable, effective, and easy to apply for the client. Rehabilitation vendors now have a wide selection of thermoplastic materials for custom orthotic fabrication; however, since the turn of the century, therapists' perspectives on considerations for thermoplastic material selection are less known.

The 2019 practice analysis of hand therapy found that assessment, selection, and implementation of orthotic tasks were a daily occurrence and that therapists considered custom fabrication of orthoses a highly critical task (Keller et al., 2021). However, the health care system and reimbursement of therapy services are ever-changing (McAuliffe, 1999). There is limited information about the challenges therapists currently face specific to custom orthotic fabrication in the current health care environment.

Purpose of the Study

Despite ongoing advancements in thermoplastic materials for custom orthotic fabrication, there is limited literature regarding therapists' perspectives on thermoplastic material selection since the 1990s, and less is known about the challenges to custom orthosis fabrication. This study aimed to describe therapists' considerations for thermoplastic material selection and the barriers experienced with custom orthotic fabrication.

Method

Study Design and Recruitment

A cross-sectional descriptive research survey was used to collect data from a convenience sample of occupational and physical therapists who were members of the ASHT in 2021. The Institutional Review Board of Indiana State University reviewed and approved the study. Following approval by the ASHT research division, the electronic survey was disseminated to the ASHT membership via an email blast on August 5, 2021. A reminder email with a link to the survey was sent 2 weeks later, on August 19, 2021. At the time of the study, ASHT membership was 3,608 therapists.

Instrumentation

A preexisting survey meeting the study's objectives was not found during the literature review; however, the demographic questions were based on the template provided by ASHT for standard core demographic questions (Packham, 2021). Background information on therapists' frequency of fabricating custom orthosis was based on the scale provided in the 2019 practice analysis (Keller et al., 2021). We designed the survey on a secure Qualtrics platform based on the literature review and research questions. Two content experts and one expert in survey research established face validity. Two hand therapists completed a pilot version and provided feedback for survey modification to increase question clarity. On completion of the survey edits, the final version was submitted to the ASHT research division for review and dissemination.

The survey included four sections: (a) demographics; (b) background on custom orthotic fabrication; (c) thermoplastic material selection based on resistance to stretch, thickness, and perforations for different anatomical locations and conditions; and (d) barriers experienced with custom orthotic fabrication. Closed-ended questions were multiple choice or multiple answers with free text options available for each question for the therapists to expand or explain their rationale. One open-ended question was, "What did I not ask that you would like to add about thermoplastic material and your experience in using it?" The Checklist for Reporting Results of Internet E-Surveys (CHERRIES) was referenced for the development and execution of the study (Eysenbach, 2004).

Rehabilitation vendors that offer thermoplastic materials vary in their description of materials. However, two main suppliers (Performance Health and North Coast Medical) describe their thermoplastic product line in relation to resistance to stretch (Jacobs & Austin, 2022). Categories for choices of thermoplastic material were based on the product description provided on the vendor's website, with examples of thermoplastic material to provide context.

For example:

What is your most preferred thermoplastic material for fabricating a custom static orthosis?

1. Minimal resistance to stretch (polyform, orfit classic soft)
2. Minimal to moderate resistance to stretch (example preferred, polyflex II, orfilight, orfit colors)
3. Moderate resistance to stretch (tailor, aquaplast original, orfit classic stiff, spectrum)
4. Moderate to max resistance to stretch (ezeform, aquaplast resilient, omega max)
5. Maximum resistance to stretch (synergy, sansplint, orfit, eco black)

To identify barriers to custom orthotic fabrication, we provided broad categories from which the therapists could select. Examples were provided to explain each category. The categories were determined based on the authors' experience and modified based on the feedback of two content experts. Free text options were provided for each category for the therapists to explain their selection in more depth, and an "other" category was also provided to identify any additional barriers encountered by the therapists not provided as a choice.

For example:

> Are there any barriers you encounter during custom orthotic fabrication? Select all that apply. Please explain if possible:
>
> 1. Barriers related to reimbursement and insurance (reasonable useful lifetime of DME)
> 2. Barriers related to client factors (client willingness, perceptions, beliefs, comorbidities)
> 3. Barriers related to administrative issues (limited time)
> 4. I experience no barriers
> 5. Other

Data Analysis

Data from Qualtrics was exported to IBM SPSS statistics viewer (version 28.0) for analysis. Data were reviewed, and the responses from the students and retired therapists were eliminated to reflect current practice patterns. Descriptive statistics, including cross tabulation, percentage, and frequency of the therapist responses, were used to summarize categorical data. Spearman rho coefficients were used to describe the relationship between the therapists' years of experience, perceived level of expertise in orthoses fabrication, frequency of custom static orthoses fabrication, frequency of custom static progressive/dynamic orthoses fabrication, and barriers encountered with custom orthotic fabrication. Statistical significance was set at $\alpha = .05$ for evaluating correlations.

Data from free text comments and the open-ended question were compiled and coded with the frequency of responses by the authors individually. The categories were then established using content analysis (Graneheim & Lundman, 2004).

Results

Demographics

The survey was sent electronically via email to members of ASHT (n = 3,608 at the time of the study). A total of 371 therapists responded to the survey, and 349 therapists provided informed consent to participate in the study. The responses from the students and retirees were excluded from data analysis to reflect current practice patterns, resulting in 333 participants. The 333 respondents did not answer all of the questions. Frequency and percentages of responses are presented based on the number of responses and provided with tables and figures. The participants are referred to as therapists. Tables 1 and 2 provide relevant details of the therapist demographics and custom orthoses fabrication practices.

A weak correlation ($r = .16$, $p < .001$) was found between years of experience in hand therapy and the frequency of custom orthotic fabrication. Even though significant, the coefficient of determination indicates only 2.5% of explained variance, a small relationship. Similarly, a weak correlation ($r = .19$, $p < .001$) was found between the perceived level of proficiency in splint fabrication and the frequency of fabricating and designing dynamic orthosis with only 3.6% of explained variance. Years of experience in hand therapy practice and perceived level of proficiency in custom fabrication of orthosis exhibited a significant low correlation ($r = .39$, $p < .001$).

Table 1

Demographics of Therapists

	N	Responses	Frequency n (%)
Profession	333	Occupational therapist	311 (93)
		Occupational therapy assistant	1 (.3)
		Physical therapist or Physiotherapist	20 (6)
Years of experience in hands (*M* = 21 years, range < 1 to 48)	333	≤ 1	11 (3.3)
		2 to 5	35 (10.5)
		6 to 10	49 (14.7)
		11 to 20	71 (21.3)
		> 20	165 (49.8)
Certified hand therapist		Yes	286 (86.1)
Highest degree earned	332	Bachelor's degree	138 (41.6)
		Post professional Master's degree in OT or PT	93 (28)
		Master's degree in another field (MBA, Med)	37 (11.1)
		Post professional clinical doctorate in OT or PT	50 (15.1)
		Clinical doctoral degree in another field (DrPH)	2 (.6)
		Academic doctoral degree (PhD, EdD)	5 (1.5)
Current primary practice setting	332	Hospital-based outpatient clinic	132 (39.8)
		Physician-owned outpatient clinic	70 (21.1)
		Therapist-owned outpatient clinic	45 (13.6)
		Corporate-owned free standing outpatient clinic	37 (11.1)
		Private practice independent practitioner	17 (5.1)
		Academic-based outpatient clinic	11 (3.3)
		Academia and research	11 (3.3)
		Inpatient hospital and rehab	5 (1.5)
		Other	4 (1.2)
Perceived level of proficiency with fabrication of custom orthosis	332		
		Extremely proficient	233 (70.2)
		Moderately proficient	87 (26.2)
		Minimally proficient	12 (3.6)

Note. MBA = Master of Business Administration; Med = Master of Education; DrPH = Doctor of Public Health; PhD = Doctor of Philosophy; EdD = Doctorate in Education.

Table 2

Frequency of Custom Orthoses Fabrication

	Number of therapists	Min	Max	Mean	SD
Custom orthosis as a treatment intervention	332	1	5	3.78	.906
Custom static orthosis fabrication	332	1	5	3.67	.953
Custom static progressive orthoses fabrication	332	1	5	2.4	.668
Custom dynamic orthoses fabrication	330	1	4	2.02	.562

Note. Frequency: 1 = *never*; 2 = *rarely* (monthly or less); 3 = *sometimes* (weekly or almost weekly); 4 = *often* (daily or almost daily); 5 = *repeatedly* (several times a day).

Thermoplastic Material Properties Considered for Custom Orthotic Fabrication

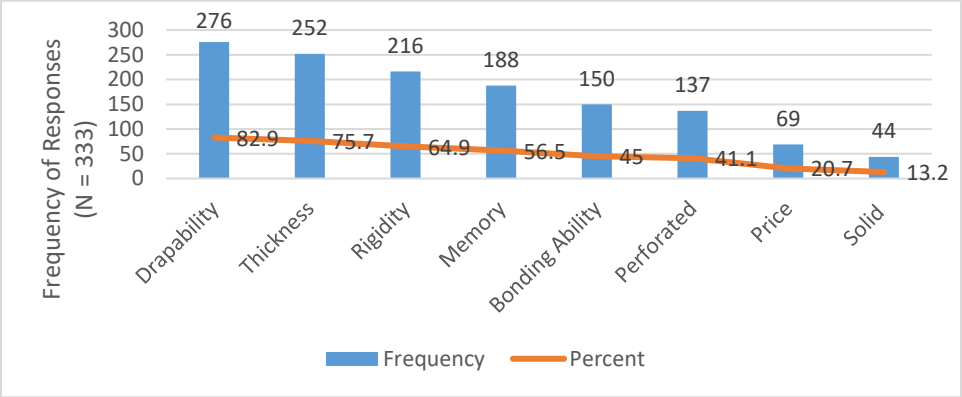
Drapability, followed by thickness, rigidity, and memory, were the more frequently considered material properties. The price of the material was low in consideration (see Figure 1).

Therapist Selection of Materials Based on Resistance to Stretch (N = 294)

Materials with moderate resistance to stretch were the most preferred thermoplastic material selected for both static (n = 120, 40.8%) and dynamic orthosis (n = 118, 40.1%). Materials with minimal to moderate resistance to stretch were the second most preferred material for static orthosis (n = 86, 29.2%), while moderate to maximum resistance stretch was the second most commonly used material for dynamic orthoses (n = 60, 20.4%). Common themes from free text categorization of responses included: (a) preferred use of materials with less resistance to stretch with patients with high tone (n = 5) and (b) selection of materials dependent on hand size and body part with a more drapable material selected for hand-based and digital orthoses (n = 6).

Figure 1

Material Properties Considered for Custom Orthotic Fabrication



Therapist Selection of Materials Based on Thickness (N = 333)

In general, the therapists preferred thinner 1/16" materials for digital orthosis (n = 178, 53.5%), thicker 1/8" materials for forearm-based orthosis (n = 188, 56.5%), and 1/8" thickness for long arm orthosis (n = 241, 72.4%). Thickness of material preferred by the therapists for hand-based orthosis was somewhat equally distributed between 3/32" and 1/8" materials (n = 80, 24% and n = 99, 29.7%, respectively). Free text comments provided further insight into the therapists' considerations when selecting thickness of material. The categories that emerged include: (a) occupation and activity level (n = 5) and (b) size of forearm, hand, and digits (n = 12). Comments included: "Generally, 1/16" for digits. Exception would be a manual laborer who might need a thicker 1/8" durable material" and "3/32 if they are petite, 1/8 if they are big/heavy."

Therapist Selection Based on Perforation of Materials (N = 333)

While there was a preference for perforated materials (n = 137, 41.1%) over solid materials (n = 44, 13.2%), common themes that emerged from free text comments provided insight into the therapist considerations and included: (a) rigidity of solid materials (n = 10), (b) breathability of perforated materials (n = 15), and (c) smoothness of edges (n = 3). The following are the representative quotes:

- "I like splints that need more strength to be not perforated."
- "Solid for most but thin perforated for mallet and skin maceration."
- "Perforated especially in hot summer."
- "Usually solid; highly perforated can result in rougher edges."

Barriers Experienced with Custom Fabrication of Orthoses

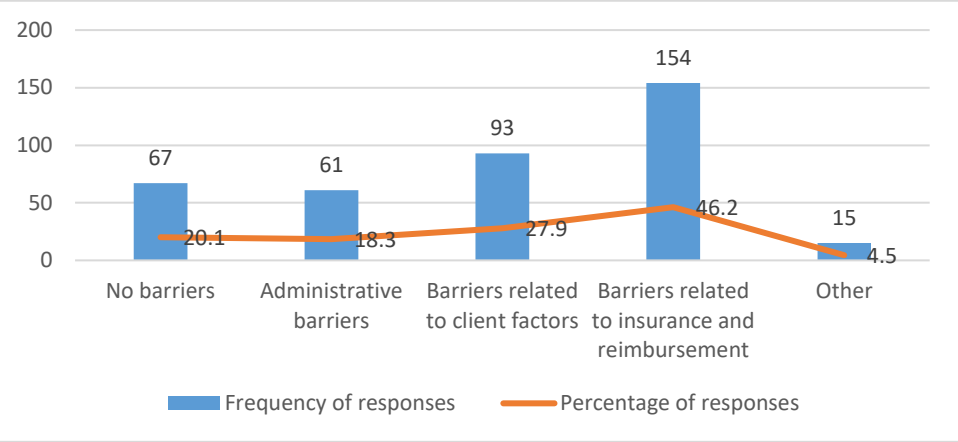
About 80% of the therapists experienced barriers with custom fabrication of orthosis. Figure 2 presents a summary of the therapists' selections of barriers listed in the survey. The "other" category was selected by 4.5% (n = 15) of the therapists to describe additional perceived barriers. Data from the free text options of the "other" category revealed two main additional challenges for therapists (a) personal barriers related to knowledge and skill level (n = 3) and (b) physician preference for prefabricated orthoses (n = 3). Cross tabulation of the therapists who noted personal barriers were newer to hand therapy practice at ≤ 1 year.

About 20% of the therapists (n = 67) selected the category of facing "no barriers." No significant correlation was found between practice locale, frequency of orthoses fabrication, and selection of facing "no barriers" (r = .09, p = .07). A low but significant correlation was found between higher perceived level

of proficiency with custom orthotic fabrication and selection of facing "no barriers" ($r = .24$, $p \leq .001$). But high perceived level of proficiency explained only 5.8% of the variance, a small relationship.

Figure 2

Barriers to Custom Orthotic Fabrication (N = 333). Multiple Answers Allowed.



Barriers Related to Insurance and Reimbursement

The therapists selected this category the most frequently in the barriers experienced with orthotic fabrication (n = 154, 46.2%). Cross tabulation of practice setting locale and barriers to custom orthotic fabrication revealed that insurance and reimbursement were the most frequently selected barriers for outpatient settings.

Themes from the free text responses for barriers related to insurance and reimbursement were categorized and included in Table 3 with representative quotes. Limits on reimbursement was the most frequently encountered challenge.

Table 3

Barriers Related to Insurance and Reimbursement

Categories	Frequency of responses	Representative Quotes
Limits on reimbursement	n = 26	"We are not Medicare certified and do not bill L-codes, this has seriously impacted reimbursement" "DME coverage varies" "HMOs don't reimburse"
High patient cost	n = 22	"Cost for patient based on deductible or coinsurance" "Due to not being a DME provider some patients have out-of-pocket expenses" "Occasionally financial difficulties for patient due to final 20% pay"
Preauthorization difficult to obtain timely	n = 11	"Prior authorization is difficult to obtain for post op pt coming from ortho office." " Needing to wait on prior authorization (work comp) before fabrication, which is an immediate need but doesn't get an immediate response or a denial when it's medically necessary to protect injury/post-op"
Reasonable useful lifetime for orthosis	n = 8	"MCR has restrictions on DME to 5 yrs" "Only one every 5 years for certain insurances, especially for highly involved individuals (i.e., RA deformities)" "Difficulty if patients need a new splint for a chronic condition or if splint is lost, etc."

Note. DME = Durable medical equipment; ortho = orthopedic; work comp = workers compensation; MCR = medicare; RA = rheumatoid arthritis.

Barriers Related to Client Factors

Challenges related to client factors were the next most frequently selected barrier by the therapists (n = 93, 37.9%). Categories that emerged from the free text in this area with representative

quotes are described in Table 4. Lack of client compliance with orthosis wear was the most mentioned challenge.

Table 4

Barriers Related to Client Factors

Categories	Frequency of responses	Representative Quotes
Compliance	n = 19	"I find most patients do not like or adhere to splint wearing schedule unless they are post op. I don't make them as much as I used to due to limited patient compliance." "Patient compliance, ADL that interfere with orthosis wear" "I always ask patients if they will really wear the splint and have examples to show them prior to fabrication. No point in wasting time if they do not like the splint and will not wear it."
Patient comfort	n = 6	"Some patients do not like the rigidity of the orthosis" "Patient preference is a huge factor in choice of prefab vs custom" "Tolerance/skin issues"
Client comorbidities	n = 5	"Spasticity" "Impaired cognition"

Note. Post op = post operation; ADL = activities of daily living; Prefab = prefabricated; vs = versus.

Administrative Barriers

The therapists selected administrative barriers the least frequently (n = 61, 18.3%). There was a very weak significant correlation between years of experience in hand therapy and challenges experienced in this category (r = .167, p = .016). No significant correlation was found between the level of proficiency and challenges experienced in administrative barriers (r = .088, p = .108). Common themes from the free text in this category primarily included limited available material (n = 18) and the lack of sufficient time (n = 12). Material availability reflected challenges in the supply of thermoplastic materials from market complications of COVID-19 as well as limited options of materials based on company policy. Time-related issues included a lack of sufficient scheduled time, accommodating walk-ins, and the time required to fabricate dynamic orthoses. Representative quotes from the therapists providing insight on administrative barriers included:

- "I am limited to ordering from one company; therefore, I have less options from [the] Northcoast but find they offer enough to make majority of orthoses I need."
- "Small clinic, limited supplies."
- "Limited time for dynamic splinting."
- "Again, we were shocked in our clinic that thermoplastic material was not easily able to be found/purchased with the factory shutdowns due to Covid."
- "Often, a walk in needs much in addition to an orthosis, so [I] often work through lunch or others must take my next patient etc."

Discussion

The study aimed to describe therapists' considerations for thermoplastic material selection and barriers experienced with custom orthotic fabrication in hand therapy practice. The survey research design was selected to answer the research question. Data from the 332 responding therapists, 9.2% of the population of ASHT membership, is summarized. The results from surveys have shown acceptable validity in providing information to move research and practice forward (O'Brien & McGaha, 2014).

Therapist Selection of Thermoplastic Material

Drapability, thickness, and rigidity of the thermoplastic material were the main material properties therapists considered when selecting thermoplastic material. Price was a low consideration. These findings are similar to the study done by Lee (1995), where conformity, thickness, and flexibility were the main considerations for the selection of material; however, cost was also a main factor identified in that study.

The cost difference over the 30-years between the studies was not found. The role of the therapists in ordering thermoplastic material was not explored in this study.

Drapability and conformability of the material refer to the ability of the material to mold around the contours of the client's anatomy; drapability increases with materials offering low resistance to stretch (Schofield & Schwartz, 2019). More drape was preferred for hand-based and digital orthoses, but if higher strength was desired, materials with less drape were preferred. Textbooks suggest similar recommendations: low-conforming materials are better suited for larger orthoses (Fess et al., 2005; Schofield & Schwartz, 2019). The most selected thermoplastic material for fabricating custom static orthoses were those that provided moderate resistance to stretch, followed by materials with minimal to moderate resistance to stretch. The most selected material for fabricating dynamic orthoses was moderate resistance to stretch followed by moderate to maximum resistance to stretch, which can be interpreted as more strength in material desired to sustain mobilizing forces.

The thickness of thermoplastic material has a direct effect on the rigidity of a fabricated orthosis; thinner materials weigh less but provide reduced support (Schofield & Schwartz, 2019). With this trade-off in mind, textbooks generally recommend using thicker materials to support larger body parts and thinner materials for smaller body parts (Jacobs & Austin, 2022; Schofield & Schwartz, 2019). The therapists in this study most commonly selected 1/8" thick materials for elbow orthoses and forearm-based orthoses, 1/16" thick materials for digital-based orthoses, and an approximately equal preference for 1/8" or 1/16" thickness for hand-based orthoses. However, free text comments explained that the therapists' selection of the thickness of the material is contextual. Client factors that the therapists' considered when selecting the thickness of the material included the client's occupations and activity level and the anthropometrics of the forearm, hand, and digit. These considerations are similar to the recommendations found in the literature. High rigidity, the ability to resist deformation from an external force, was recommended when selecting thermoplastic material for clients in construction or manual material handling where high external forces were anticipated (Jacobs & Austin, 2022).

Thermoplastic materials are available in perforated and non-perforated forms. Perforated materials were more preferred for custom orthoses fabrication compared to solid materials by the therapists, but free-text comments explained the therapists' selection of solid versus perforated material was contextual. The use of solid materials was preferred for more rigidity and smooth edges, and the use of perforated materials was preferred to provide ventilation. General recommendations in the literature are similar, with guidelines to use perforated materials in warmer climates and solid products to offer rigidity and reduce the risk of localized area of weakness with stretching of material for clients who perspire a lot or have open wounds (Schofield & Schwartz, 2019). In addition, the literature indicates that where dual needs of rigidity and ventilation are needed, a circumferential design using perforated material may be an appropriate option (Jacobs & Austin, 2022).

Challenges to Custom Orthoses Fabrication

The main barriers experienced by the therapists were related to insurance and reimbursement, followed by client factors and then administrative factors. However, 20% of the therapists reported experiencing no barriers to custom orthoses fabrication. The results of our study did not reveal why some therapists experience challenges and others do not, with only a weak correlation found between high perceived level of proficiency in custom orthotic fabrication and experiencing no barriers ($r = .25$). Future studies exploring psychosocial factors and the administrative role of therapists might provide better insight into factors that contribute to a therapist experiencing no barriers in custom orthotic fabrication.

Reimbursement and insurance-related issues were the most frequently cited challenge in all outpatient settings, irrespective of the type of outpatient. Although analysis of specific factors related to navigating insurance reimbursement is beyond the scope of this study, the therapists encountering barriers provided insight into the challenges to sustainable and appropriate care posed by limitations in reimbursement; procuring insurance approval; and the need to stay abreast on policies of durable medical equipment prosthetics, orthotics, and supplies (DMEPOS). From a therapist's perspective of challenges to providing hand therapy in the health care environment of the new millennium, increased administrative time to obtain authorization for orthosis, getting on the list of a participating network, and limited coverage of orthosis were among the many unfavorable effects listed by the author (Miller, 1999).

Compliance with wear of the orthoses was the most frequently cited challenge encountered by the therapists in the category of client-related factors. Compliance has been described as the most unpredictable and least controllable variable in medical intervention (Groth & Wulf, 1995). In a study exploring client adherence with orthosis wear following tendon repairs, the authors found that only 33.1% of the clients were fully adherent, 50.4% were partially adherent, and 22% were non-adherent (Savaş & Aydoğan, 2022). A systematic review studying adherence to orthotic use in adult patients with upper-extremity injuries identified comfort, immediacy in benefits, and minimal intrusion in daily activities as the factors related to improved client adherence (O'Brien, 2010). A qualitative study of three clients emphasized the importance of the client's input, outlining client-centeredness, comfort, cosmesis, convenience, less is more, and follow-up as six essential considerations for orthotic use (McKee & Rivard, 2004). Since compliance plays a critical role in determining successful outcomes of therapeutic intervention (Groth et al., 1994), incorporating factors contributing to client adherence should be part of the thermoplastic material selection process.

Material availability, followed by lack of sufficient time, were the challenges most reported by the therapists in the category of administrative barriers. The therapists noted that purchasing contracts with suppliers limited choices of materials in their inventory. Lack of sufficient time for dynamic splinting was a frequently mentioned challenge. There was no significant correlation with a perceived level of proficiency, years of experience, and barriers faced in this category. The therapist comments that the complexity of the client's presentation and the need to accommodate walk-in patients in their schedule explained some of the reasons therapists experience this challenge. Rossi, in a 1988 study on concepts and trends in orthotic intervention, identified that increased patient load and decreased treatment time are factors that influence the selection of prefabricated orthoses. Collaboration between supervisors and therapists to balance productivity standards and allow sufficient time for patient care is an essential ongoing conversation.

Challenges for Newer Therapists

A study describing custom orthotic fabrication education in occupational therapy curricula in the United States found considerable variability in course structure and content (Schofield & Schwartz, 2019). On average, students made two to five orthoses during their course. Although quantifying the variety of thermoplastic materials students were exposed to was not included in the study, many faculty reported increasing exposure to different materials as part of the plan for course improvements (Schofield & Schwartz, 2019). Since the therapists in our study used custom fabrication of orthoses as a treatment intervention weekly to daily in their practice, exposure to a wide range of materials during training would allow therapists to understand the options available in this critical aspect of hand therapy.

Our findings of no significant correlation between years of experience in hand therapy and frequency of using custom orthoses as a treatment intervention suggest that a newer hand therapist may fabricate custom orthoses just as frequently as a therapist with extensive experience. This can be challenging, as evident in three of the eleven therapists that had one or less year of experience in hand therapy reporting limited skill in custom fabrication of orthosis. However, our low correlation between years of experience and perceived proficiency in orthosis fabrication suggests confidence in custom orthoses fabrication develops early in the career of the hand therapist with the sheer volume of orthoses fabricated. Mentorship and resources for continuing education provide opportunities for therapists to develop their skills; however, these avenues may not be readily available or accessible to all transitioning to this field.

Limitations

Non-response bias is the main limitation of this study, with a low response rate to the questionnaire. A reminder email was sent 2 weeks after the initial dissemination to increase the rate of participation. Not all questions were answered by the therapists, and the open-ended question and free text options may have caused survey fatigue. One participant wrote that the selection of thermoplastic material was too contextual to be able to write in a free-text response. Frequency and percentages were calculated based on the number of responses, and correlations were determined from select data to minimize the effect of this limitation. The sample of therapists, however, represented all levels of experience in hand therapy, from less than one year to more than 20 years. This provided an opportunity to analyze the relationship between years of experience with use and barriers experienced with custom orthotic fabrication.

Although face validity was established for the survey through the evaluation of content experts, and revisions were made based on feedback from the pilot version, a few questions may have been misinterpreted by some therapists. One participant wrote that it is unclear if the question asked about barriers for the client or the therapist in custom fabrication of orthoses. This misinterpretation occurred despite our questionnaire providing explanations and examples for the categories of barriers to custom orthotic fabrication. Since providing too many examples may create a bias toward certain answers, revealing several different themes from these categories beyond the examples provided suggests that the bias was minimized.

Convenience sampling resulted in a majority of the responding therapists to be from an outpatient setting with minimal representation of other settings in this study. Barriers and challenges in other settings might be different compared to outpatient settings. However, our sample of therapists is reflective of other recent survey studies exploring the views of members of ASHT where majority of therapists worked in outpatient clinics (O'Brien & McGaha, 2014; Parish et al., 2020).

Future studies that explore therapist preference of thermoplastic materials in different practice settings and populations, preference for prefabricated versus custom orthoses, and an in-depth study of insurance-related barriers from multiple stakeholders' perspectives would be valuable to improving the delivery of this valued intervention.

Conclusion

This study's objective was to describe hand therapists' considerations for thermoplastic material selection and the barriers therapists experienced with custom orthoses fabrication. Drapability, thickness, and rigidity of the thermoplastic material were the main material properties that the therapists in this study considered for selection of thermoplastic material. Price was low on the consideration. Thermoplastic material selection for a client was contextual with the occupation of the client, activity level, size of the

body part, anatomical segments involved, presence of wounds, climate, purpose of orthoses (to mobilize or immobilize), comorbidities being some of the factors the therapists considered when selecting thickness, drapability, perforations, and rigidity of the material. While the ideal number of varieties in thermoplastic material to stock was undetermined, having variations in resistance to stretch, thickness, and perforated or non-perforated forms gives therapists an opportunity to fabricate a custom orthosis based on the client's needs. Therapists with less experience in hand therapy may likely fabricate orthoses just as frequently as an experienced therapist, and increasing exposure to different materials in therapy curricula may increase the level of preparedness. Barriers to custom fabrication of orthosis were reported by 79.9% of the therapists and were largely related to reimbursement limitations. Orthotic fabrication is integral to hand therapy practice, but the provision of this service is challenging in the current health care environment.

References

American Society of Hand Therapists. (2002). *American Society of Hand Therapists position statement on the use of orthotics in hand therapy*. https://asht.org/practice/practice-management/position-statements

Breger-Lee, D. E., & Buford, W. L., Jr. (1992). Properties of thermoplastic splinting materials. *Journal of Hand Therapy*, *5*(4), 202–211. https://doi.org/10.1016/S0894-1130(12)80274-2

Eysenbach, G. (2004). Improving the quality of web surveys: The checklist for reporting results of internet e-surveys (cherries). *Journal of Medical Internet Research*, *6*(3), e34. https://doi.org/10.2196/jmir.6.3.e34

Fess, E. E. (2002). A history of splinting: To understand the present, view the past. *Journal of Hand Therapy*, *15*(2), 97–132. https://doi.org/10.1053/hanthe.2002.v15.0150091

Fess, E. E., Gettle, K. S., Philips, C. A., & Janson, J. R. (2005). Construction principles. In Elain Fess (Ed.), *Hand and upper extremity splinting* (3rd ed., pp. 237–251). Elsevier.

Graneheim, U. H., & Lundman, B. (2004). Qualitative content analysis in nursing research: Concepts, procedures and measures to achieve trustworthiness. *Nurse Education Today*, *24*(2), 105–112. https://doi.org/10.1016/j.nedt.2003.10.001

Groth, G. N., Wilder, D. M., & Leroy Young, V. (1994). The impact of compliance on the rehabilitation of patients with mallet finger injuries. *Journal of Hand Therapy*, *7*(1), 21–24. https://doi.org/10.1016/S0894-1130(12)80037-8

Groth, G. N., & Wulf, M. B. (1995). Compliance with hand rehabilitation: Health beliefs and strategies. *Journal of Hand Therapy*, *8*(1), 18–22. https://doi.org/https://doi.org/10.1016/S0894-1130(12)80151-7

Jacobs, M. A., & Austin, N. M. (2022). *Orthotic intervention for the hand and upper extremity* (3rd ed.). Wolters Kluwer.

Joseph, M., Constant, R., Rickloff, M., Mezzio, A., & Valdes, K. (2018). A survey of client experiences with orthotics using the quest 2.0. *Journal of Hand Therapy*, *31*(4), 538–543, e531. https://doi.org/10.1016/j.jht.2018.07.002

Keller, J. L., Henderson, J. P., Landrieu, K. W., Dimick, M. P., & Walsh, J. M. (2021). The 2019 practice analysis of hand therapy and the use of orthoses by certified hand therapists. *Journal of Hand Therapy*, *35*(4), 628–640. https://doi.org/10.1016/j.jht.2021.04.008

Lee, D. B. (1995). Objective and subjective observations of low-temperature thermoplastic materials. *Journal of Hand Therapy*, *8*(2), 138–143. https://doi.org/10.1016/s0894-1130(12)80311-5

McAuliffe, J. A. (1999). Hand care in the new millennium: Surgeon's perspective. *Journal of Hand Therapy*, *12*(2), 178–181. https://doi.org/10.1016/S0894-1130(99)80022-2

McKee, P., & Rivard, A. (2004). Orthoses as enablers of occupation: Client-centred splinting for better outcomes. *Canadian Journal of Occupational Therapy*, *71*(5), 306–314. https://doi.org/10.1177/000841740407100510

Miller, R. E. (1999). Hand care in the new millennium: Therapist's commentary. *Journal of Hand Therapy*, *12*(2), 182–183. https://doi.org/10.1016/S0894-1130(99)80023-4

O'Brien, L. (2010). Adherence to therapeutic splint wear in adults with acute upper limb injuries: A systematic review. *Journal of Hand Therapy*, *23*(4), e12–e13. https://doi.org/https://doi.org/10.1016/j.jht.2010.09.029

O'Brien, V. H., & McGaha, J. L. (2014). Current practice patterns in conservative thumb CMC joint care: Survey results. *Journal of Hand Therapy*, *27*(1), 14–22. https://doi.org/10.1016/j.jht.2013.09.001

Packham, T. (2021). *Standard set of demographic questions*. https://asht.org/research/research-studies/research-surveys

Parish, R., Morgan, C., Burnett, C. A., Baker, B. C., Manning, C., Sisson, S. K., & Shipp, E. R. (2020). Practice patterns in the conservative treatment of carpal tunnel syndrome: Survey results from members of the american society of hand therapy. *Journal of Hand Therapy*, *33*(3), 346–353. https://doi.org/10.1016/j.jht.2019.03.003

Rossi, J. (1988). Concepts and current trends in hand splinting. *Occupational Therapy in Health Care*, *4*(3–4), 53–68. https://doi.org/10.1080/J003v04n03_06

Savaş, S., & Aydoğan, Ç. (2022). Factors affecting orthosis adherence after acute traumatic hand tendon repairs: A prospective cohort study. *Journal of Hand Therapy*, *35*(1), 32–40. https://doi.org/10.1016/j.jht.2020.10.005

Schofield, K., & Schwartz, D. (2019). *Orthotic design and fabrication for the upper extremity*. Slack Inc.

Schofield, K. A., & Schwartz, D. A. (2019). Teaching orthotic design and fabrication content in occupational therapy curricula: Faculty perspectives. *Journal of Hand Therapy*, *33*(1), 119–126. https://doi.org/10.1016/j.jht.2018.08.003

Shimeld, A., Campbell, G., & Ernest, M. (1984). Clinical results of a comparative evaluation of splinting materials. *Canadian Journal of Occupational Therapy*, *51*(2), 81–91. https://doi.org/10.1177/000841748405100203