Hanger Institute FOR CLINICAL RESEARCH & EDUCATION®

2024-25 ANNUAL REPORT

Hanger Institute

FOR CLINICAL RESEARCH & EDUCATION®

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Embedded within Clinical & Scientific Affairs at Hanger Clinic, The Hanger Institute for Clinical Research and Education is an assembly of experts and resources dedicated to advancing clinical practice and improving patient outcomes through leading-edge research, evidence-based care, and quality education.

Through strategic collaboration, associates and affiliates of the Hanger Institute accelerate the mission of Hanger Clinic to benefit patients requiring orthotic and prosthetic (O&P) rehabilitation. Our mission is to explore, expand, and facilitate opportunities that advance the science and care in O&P.

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A Letter from our Chief Clinical Officer

Dear Friends and Colleagues,

I am honored to introduce the Hanger Institute for Clinical Research and Education's 2024-2025 Annual Report in my first year as Chief Clinical Officer. I step into this role with deep respect for the remarkable work that has brought us to this point, and with a focused vision for the path ahead.

In a healthcare landscape that increasingly demands measurable outcomes, the O&P profession must not only demonstrate the value we deliver, but also actively shape it. This past year, the Hanger Institute has made meaningful progress toward that goal through research, innovation, and clinical integration. We continued to generate critical evidence in support of microprocessor technologies and contributed foundational work in bone-anchored prosthetics. We advanced novel outcome measures that better capture the real-world impact of care and explored the integration of artificial intelligence to enhance clinical decision-making. Most importantly, we elevated the voice of the patient—incorporating patient preferences more directly into our care pathways and outcomes research.

Our contributions have also extended beyond data. Through the Hanger LIVE 2025 event and global education forums, we helped shape the future of O&P care. We continued our commitment to knowledge translation and education through clinical residencies, peer-reviewed publications, and partnerships that connect research to practice.

As you'll see throughout this report, the Hanger Institute is not just measuring value—we are actively building it. This means investing in science, empowering clinicians, engaging with patients, and aligning our work with the broader goals of the healthcare system.

To our partners, collaborators, clinical teams, and the hundreds of patients who have generously contributed their time and energy—thank you. Your unwavering commitment is the foundation of this work. Together, we are advancing O&P care by helping everyone realize its true value.

Our value is not measured by the volume of lives we touch, but by the meaningful change we bring to each individual.

Shane Wurdeman, PhD, FAAOP(D)
Chief Clinical Officer

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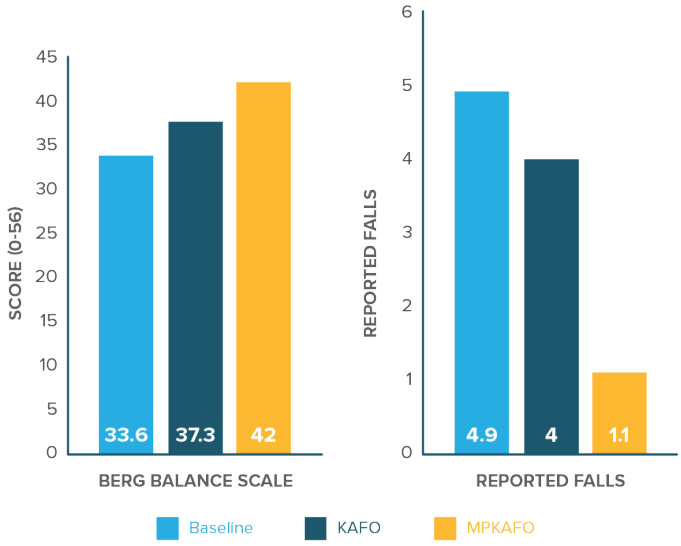
Enabling Improved Outcomes with Microprocessor Technology

The impact of microprocessor control on improving the safety and mobility of individuals with transfemoral prostheses who are active walkers in their communities has long been realized. More recently, microprocessors have been successfully integrated into lower limb orthoses and prosthetic knee joints designed for more limited walkers. The Institute has been very active in measuring the impact of these new technologies in the lives of these new patient populations, informing clinicians and policymakers on the realized value of these interventions.

Microprocessor Controlled KAFOs Improve Balance and Mobility

The Hanger Institute recently collaborated with Ottobock on an international, multi-site clinical trial assessing the impact of microprocessor-controlled knee-ankle-foot orthoses (MPKAFOs) on individuals who rely on traditional KAFOs for ambulation. Conducted from 2019 to 2022, the randomized controlled trial included 102 participants across 13 research sites, including Hanger Clinic locations in Houston, Sarasota, Chicago, and Seattle (Ruetz et al., 2024). Although Hanger sites represented fewer than half of the study locations, their clinicians recruited more than half of the participants.



Average outcome measure scores: Baseline vs. KAFO vs. MPKAFO

Figure 1: MPKAFOs were associated with significant improvements in the Beg Balance Scale, a measure of static and dynamic balance. In addition, MPKAFOs were associated with a significant reduction in the number of reported falls.

Results showed that using a microprocessor-controlled KAFO significantly improved balance and mobility. Participants had higher Berg Balance Scores (BBS) with the MPKAFO than with traditional KAFOs (Figure 1), and fewer orthosis users were classified as high fall risk (BBS <45). Additionally, reported falls decreased by 80% with the MPKAFO compared to traditional KAFO use (Figure 1). This validation of the clinical utility and efficacy of this intervention created the foundation of a structured MPKAFO program within Hanger Clinic.

Implementation of a Standardized MPKAFO Program

Recognizing both the potential benefits of MPKAFO technology for appropriate patients and the complexity of these devices, the Hanger Institute identified a need for structured clinical support. Many orthotists had limited exposure to this technology, presenting a barrier to widespread adoption. In response, the Institute established a structured MPKAFO program designed to expand patient access while equipping clinicians with the necessary resources and training to optimize outcomes. Hands-on educational programs were delivered in person and/or virtually across all regions at Hanger Clinic, contacting 780 clinicians, 220 physical therapists and physician partners across the USA.

To ensure continued support, internal education was posted on our learning management system for subsequent review. Daily clinical support through an expanded network of designated clinical leads was made available to support best patient outcomes with MPKAFO care. This model has ensured that appropriate patients are given access to this technology in the hands of trained clinicians with access to additional expertise when needed. Further education is planned to support continued growth of utilization of the technology and add new innovations that enter the MPKAFO space.

Preliminary MPKAFO Outcomes

Clinical outcome measures are central to the MPKAFO program, enhancing patient care through goal setting and early identification of any prohibitive issues or concerns. They also demonstrate value and support the broader expansion of access and patient advocacy efforts.

Based on clinical trial findings, a standardized set of measures was established for outcomes collection at key intervals—before treatment, 3-6 months post-delivery, and annually thereafter. These include the BBS as one of the study's original metrics for fall risk, the Orthotic Patient-Reported Outcomes – Mobility (OPRO-M) for mobility assessment, and a short form version of the PROMIS-Pain Interference.

Education of MPKAFO Innovation & Standard of Care

Collaboration, Program Development, & Process Management

Clinical Adoption & Impactful Outcomes

While the majority of data collected in 2024-2025 represents baseline assessments, initial longitudinal findings are promising. In a preliminary analysis of follow-up data, 82% of patients demonstrated improvement on the BBS. Additionally, 95% of patients showed increased mobility as measured by the OPRO-M, with 52% reporting a reduction in the extent to which pain interfered with their daily tasks at home, at work and in the community.

A comparison of average baseline and 3-6 month follow-up scores is depicted in this figure (Figure 2). These early results highlight the functional benefits of MPKAFO technology and reinforce the importance of long-term outcome tracking to ensure continued patient access to these life-changing devices.

Outcome	Baseline (Existing Orthotic Intervention)	3-6 Month Follow-Up (MPKAFO)	p-value
Berg Balance Scale	28	37.7	<0.001
OPRO-M	38.8	47	<0.001
PROMIS-Pain Interference	57.2	52.7	0.026

Balance, Mobility and Pain Interference Among Users Transitioning to MPKAFOs

Figure 2: Individuals transitioning to MPKAFOs realized significant improvements in their static and dynamic balance and mobility, as well as significant declines in the extent to which pain interfered with their daily function.

Microprocessor Knees Reduce Falls and Enable Expanded Activity Among Prosthesis Users with Limited Physical Capacity

Falls can be life-altering, especially for individuals of advanced age and/or those that have difficulty with their mobility. This is especially true for our patients with an above-knee amputation. Traditionally, individuals with an above-knee amputation that were considered at a Medicare functional level K2 (e.g., limited community ambulators that could manage familiar level surfaces and the occasional ramp or stairs) were largely limited to non-microprocessor knee options.

However, advancements in science and policy have brought a welcome expansion to the options that can be considered for this population, including microprocessor knees (MPKs) where appropriate (Figure 3).

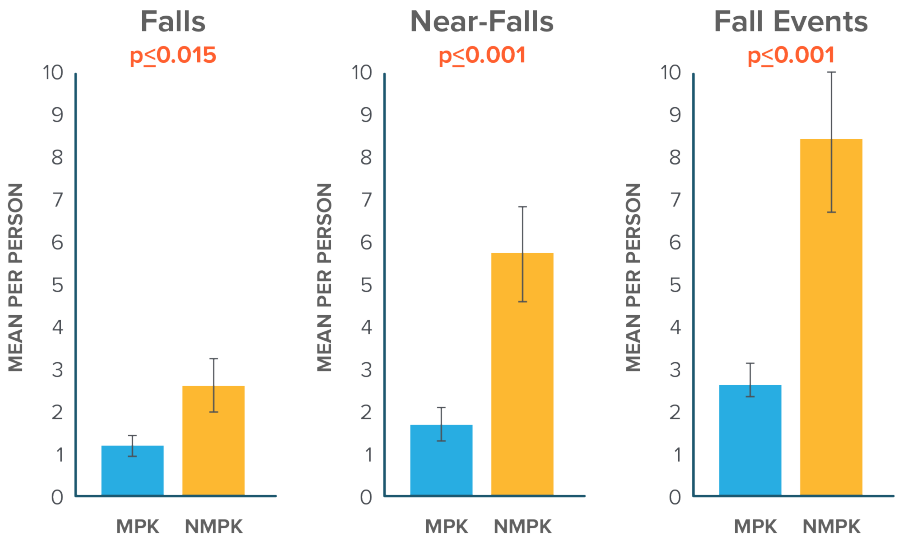
Expanded Access to Microprocessor Knees

Figure 3: Access to microprocessor knees among limited walkers has been shown to reduce falls and activity avoidance behaviors.

The field has been accumulating evidence of the benefits of MPKs for K2 patients for many years. However, these studies have typically been limited to smaller case studies, retrospective analyses, or crossover trials where smaller cohorts of individuals try a new knee for a few months then return to their original prosthesis. The encouraging observations from this broad foundation in the literature led to the origination of a large, randomized controlled study, the “ASsessing outComes with microprocEssor kNee uTilization in a K2 population” or ASCENT K2 study. The goal of this effort was to recruit 100 individuals at a K2 functional level over 65 years old in a 12-month study with each subject randomized to either an MPK or a non-MPK.

The Institute was able to successfully recruit 107 individuals into the study over the span of 11 months. These individuals had an average age of 73.66 years old, an average prosthetic mobility score nearly a full standard deviation below average and around 4 comorbid health conditions. These scores ensured that the cohort was representative of the K2 functional level. Notably, all collected assessment scores were near the middle of the expected range, rather than the high range, so these were not borderline cases just shy of K3 function, but patients soundly classified as K2 with respect to current and potential prosthetic mobility.

At the conclusion of the 12 months, individuals randomized to the MPK reported approximately 1 fall compared to individuals randomized to the non-MPK who reported approximately 3 falls. Further, those randomized to the MPK reported approximately 2 near-falls compared to approximately 6 near-falls in the non-MPK cohort. When these two measures were aggregated, individuals that were provided an MPK had significantly fewer fall events compared to those with the non-MPK (Figure 4). We also observed a significant reduction in patient's self-reported fear of falling and avoidance behaviors (as measured by the Fear of Falling Avoidance Behavior Questionnaire) and faster Timed Up and Go scores by approximately 10 seconds (Kannenburg & Wurdeman, 2024).



Falls, Near-Falls and Cumulative Fall Events Observed with Two Different Knee Types

Figure 4: Individuals randomized to the microprocessor knee (MPK) experienced significantly fewer falls and near-falls compared to individuals randomized to the non-microprocessor knee (NMPK). Fall Events is defined as the combined total of fall and near-fall events.

This evidence, paired with recently announced policy changes from the Centers for Medicare & Medicaid Services (CMS) provide a foundation for the identification of appropriate K2 prosthetic candidates for MPKs and the reasonably expected benefits attached to that treatment plan.

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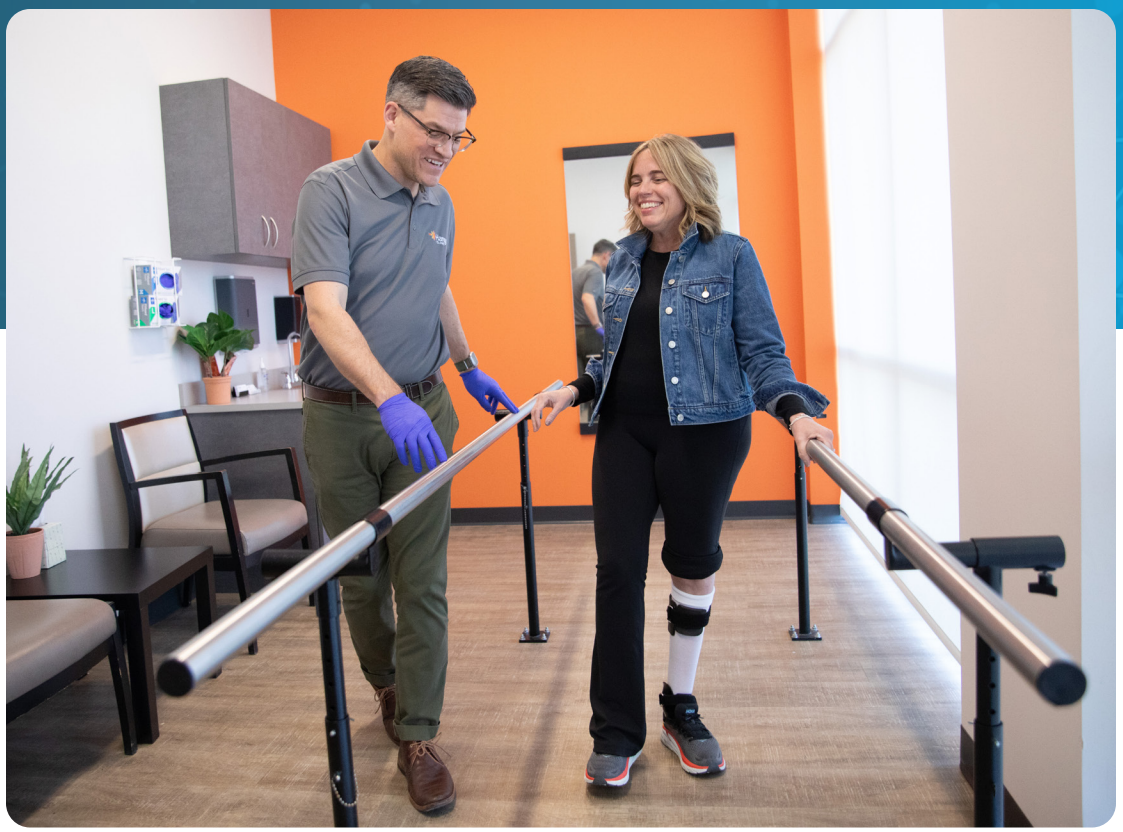


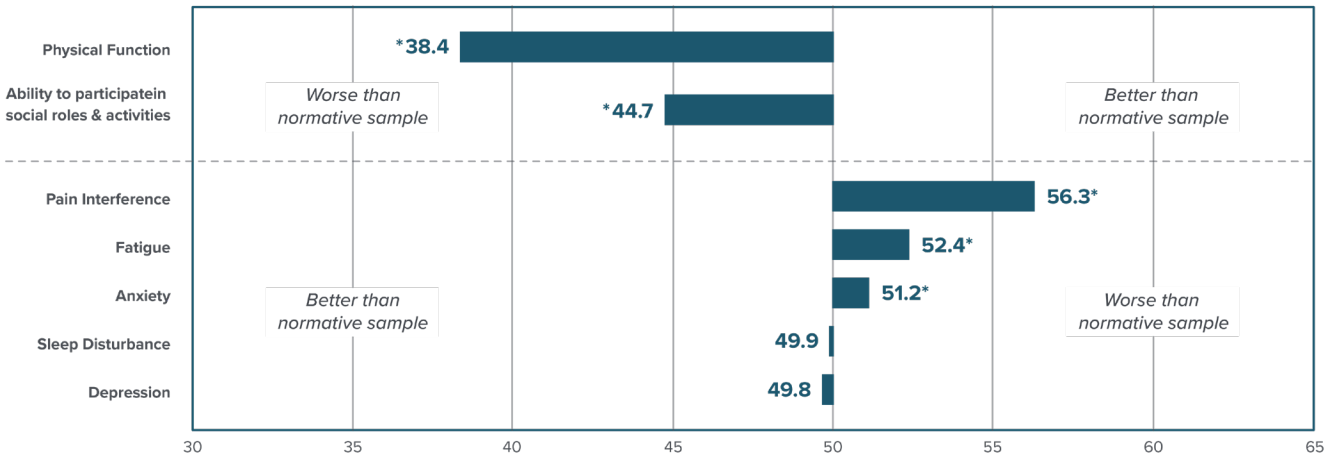
Defining Value through the Creation and Validation of Novel Outcome Measures

The collection of outcomes has been a mainstay of the Institute since its inception. This year has seen our activity in this area become more diverse as we have engaged in the creation of a number of new outcomes instruments and sought to extract added value and direction from existing measures. This has been done in collaboration with several of our valued academic partners. It includes the development of a new measure of mobility among users of lower limb orthoses, a set of novel cranial indices for infants with craniosynostosis, and utilization of big data to transform prosthetic mobility outcomes into patient-specific treatment recommendations.

Measuring Mobility Among Users of Lower Limb Orthoses

In recent years, the Hanger Institute has collaborated with our colleagues at the University of Washington to better understand the outcomes experienced by the broad range of individuals who are prescribed lower limb orthoses. Some of the foundational work in this effort was the establishment of patient-reported health profiles in this clinical community (Balkman et al., 2025). Using the PROMIS health profile reporting instrument across a diverse cohort of over 1000 users of lower limb orthoses, we were able to confirm those healthcare domains that represent the greatest concern for this population. Physical function represented the greatest divergence from index data, with the average user of lower limb orthoses reporting values more than 1 standard deviation below the mean (Figure 5). However, additional constructs of concern in this group included their ability to participate in their social roles and activities, their pain interference values and their levels of fatigue (Figure 5).

These insights were instrumental in motivating the development of the Orthotic Patient Reported Outcome – Mobility or OPRO-M (Balkman et al., 2023). Interested individuals can access the full measure at opro-m.org. Data collection and analyses are just beginning in this space as we attempt to better understand the elements that ultimately contribute to the safety and well-being of this diverse population.



Health Profiles of Lower Limb Orthoses Indexed to the General Population

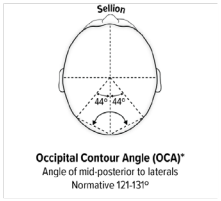
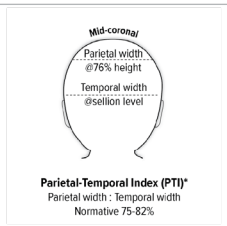
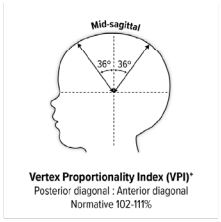
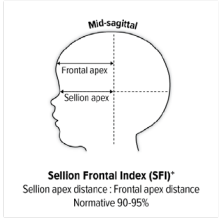
Figure 5: Average T-scores with asterisks indicate significant differences between lower limb orthosis users and the general population.

Measuring Severity of Cranial Shape

Craniosynostosis is the term used to describe the premature fusion of one or more cranial sutures. Among affected infants, the most common presentation is premature fusion of the sagittal suture. Descriptions of the resultant head shape can be mistakenly reduced to heads that appear long and narrow. While this is observed in some infants, there are additional deviations that are often present, and can more fully characterize the three-dimensional contours of the head. These include occipital narrowing or bulleting observed in the back of the head when viewed from above; narrowing of the

superior aspect of the head when viewed from in front; an elevated anterior crown of the head paired with an aggressively sloped posterior crown, best appreciated when viewed from the side; and an exaggerated frontal bossing of the brow of the head, also apparent when viewed from the side.

Historically, objective measurements of infants with sagittal synostosis were largely confined to the well-established metric of cephalic index. However, we have recognized the ineffectiveness of this index in describing both baseline severities in cranial presentation and their subsequent correction. Following surgical release of the affected suture and post-operative guidance of remaining cranial growth through the use of cranial remolding orthoses, these various elements are best corrected when they are discretely identified and monitored.

Name	Diagram	Description	Assessment Plane
OCA		Angle between occipital surface midpoint & lateralsurface, as defined by diagonals originating from sellion plane midpoint at angle θ from AP axis	Transverse (sellion)
PTI		Ratio of parietal ML & temporal diameter, w/ parietal ML diameter located at a percentage above temporal ML diameter relative to vertex	Midcoronal
VPI		Ratio of length of posterior & anterior diagonals originating from sellion plane midpoint, each angle ϕ from vertical axis	Midsagittal
SFI		Ratio of horizontal distances of sellion & frontal apex from midcoronal plane	Midsagittal

Novel Cranial Indices Created to Better Quantify the Deformation Associated with Sagittal Synostosis

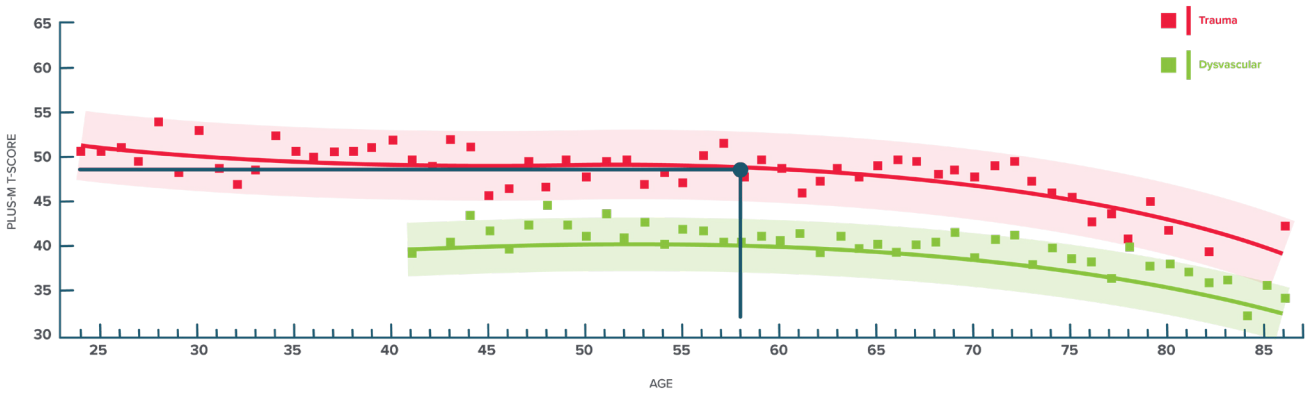
Figure 6: Four novel cranial indices were created to better quantify the aberrant head shapes associated with sagittal Synostosis. These include the Occipital Contour Angle (OCA), Parietal Temporal Index (PTI), Vertex Proportionality Index (VPI) and Sellion Frontal Index (SFI).

Partnering with the University of Utah Department of Engineering, we shared our conceptual framework for novel cranial indices to measure each of the phenomenon described above. A retrospective analysis of 25 infants before and after their course of orthotic correction allowed us to define the parameters that would be most sensitive to change in each of the indices illustrated in Figure 6. We have since operationalized these measurements in a digital platform, allowing cranial orthotists around the country to assess these new parameters throughout an infant's care to inform treatment decisions and document progress and improvement.

Predicting and Addressing the Next Steps in Lower Limb Patient Rehabilitation

With respect to users of lower limb prostheses, we continue to leverage the power of large-scale patient outcomes to assess how patients are progressing compared to their peers. This helps us in setting realistic and attainable goals and estimating the next steps in care to achieve these goals. A recent Institute publication, CASTLE 1 (Fylstra et al., 2024), enabled the determination of a patient's mobility potential as measured using the Prosthetic Limb Users Survey of Mobility (PLUS-M). Using age, amputation level, and cause of amputation, we can readily identify mean mobility values for any patient among their matched peers. This is accomplished through the newly developed mobility curves found in the CASTLE 1 manuscript (Figure 7). Similar to growth charts, these curves allow clinicians to predict where a patient's mobility should be.

For example, a 58-year-old patient with an above-knee amputation due to a motor vehicle accident might present with a current PLUS-M T-score of 39.7. Based on CASTLE 1, a similar patient with an above-knee amputation due to trauma at the same age would be expected to have a PLUS-M T-score of 49.4 (Figure 7). With this deficit identified, how can we help this patient achieve their mobility potential?



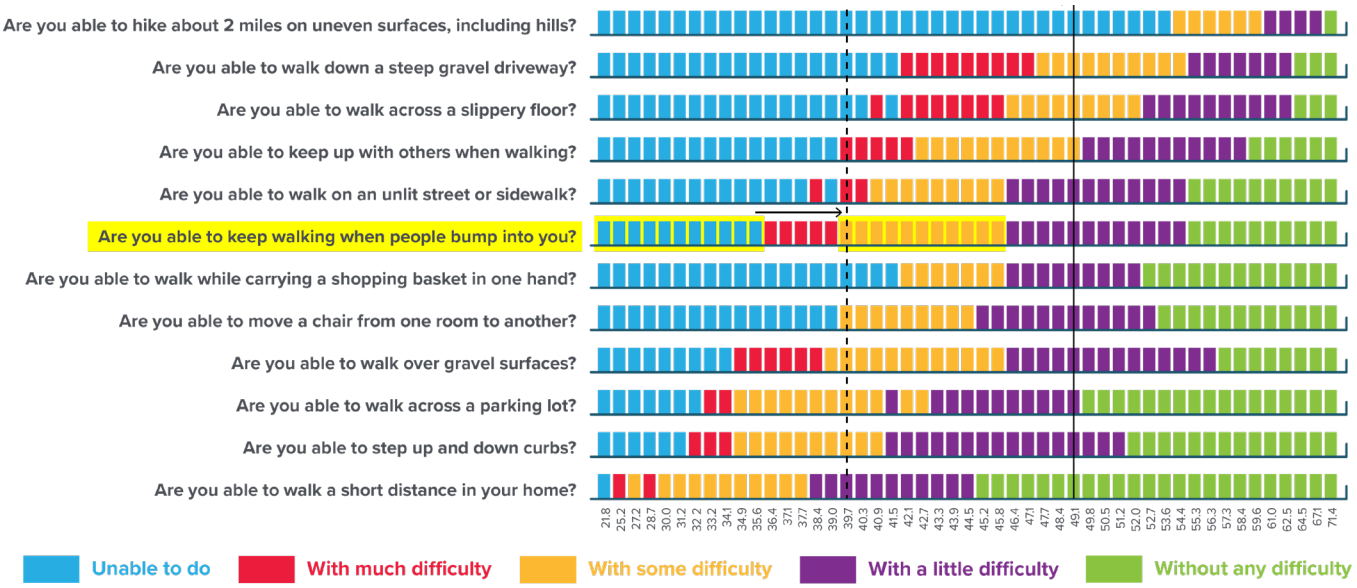
Prosthetic Mobility Curves for Individuals with Transfemoral Amputation; Predicted Mobility Value for Traumatic Amputation at Age 58

Figure 7: To use the mobility curves, draw a vertical line upwards from the patient's age on the x-axis and a horizontal line over to the y-axis. In our example, a patient with an above-knee amputation due to a traumatic accident would have the potential to achieve a T-score of 49.4.

We subsequently analyzed mobility outcomes from just under 30,000 patients to determine how individuals responded to each item on the PLUS-M to arrive at their final T-score. Participants rated their perceived difficulty on a scale from "unable to do" to "without any difficulty" across 12 items. Figure 8 below demonstrates an example map where the vertical line at T-score = 39.7 crosses the predicted response to each of the 12 items.

To identify the next steps in rehabilitation care, we can assess how the individual patient answered each of the 12 items and compare their responses to the responses predicted by the model. Continuing with our earlier example, our 58-year-old patient with an above-knee amputation may have responded "unable to do" to the item "Are you able to keep walking when people bump into you?" From Figure 8, the estimated response is "with some difficulty." This insight allows a clinician to consider how they might

improve the dynamic balance of the individual to match or exceed the values reported by their peers. This might include adjusting the alignment or components of their prosthesis or referring to physical therapy to build strength at the proximal hip joint. This information helps us pinpoint which areas of mobility are most important to this patient and provides a clearer roadmap for determining the next steps in their care.



Propensity Scores for a Each Mobility Question for a Given Prosthetic Mobility Score

Figure 8: PLUS-M™ T-score map for an individual with a PLUS-M™ T-score of 39.7 (black dashed line). This individual would be predicted to answer "with some difficulty" to the question, "Are you able to keep walking when people bump into you?" Our 58-year-old AK patient with a T-score = 39.7 answered the items and as expected, some responses were above the black dashed lines, some were below, and some were spot on compared to our prediction. As an example, he selected "unable to do" to the item about maintaining balance while bumped. As a first intervention, a prosthetist may recommend Physical Therapy to build the patient's strength or adjusting the prosthesis alignment. These changes would reflect an increase in T-score as he begins to answer "with much difficulty" or "with some difficulty" with his newfound confidence. As he continues to progress, his T-score will move closer towards the overall goal of a T-score ≥ 49.4 (black solid line).

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Foundational Work in Bone-Anchored Prosthetics

Bone-Anchored Prosthetics (BAP) is becoming increasingly common around the world. The Institute continues to recognize its role in contributing to the science and practice of BAP. In addition to its continued oversight of dozens of individual cases of transfemoral, transhumeral and transtibial BAP across the nation, this past year, members of the Institute contributed alongside a multi-disciplinary panel of experts to establish the current state of the science of BAP in meetings sponsored by the American Academy of Orthotists and Prosthetists and the American Board for Certification. This activity was paired with presentations at two international conferences, the Global Consensus Conference on Osseointegration and the Myoelectric Symposium. In addition, several members of the Hanger team contributed in a consensus exercise to establish recommendations for prosthetic component selection in this clinical space.

Control Strategies in Bone-Anchored Upper Limb Amputation

As bone-anchored prosthetics become increasingly common in lower limb applications, their use in upper limb applications has begun to enter the civilian sector. Recognizing Hanger's unique early experience in this space, members of the Institute reported upon variations in control strategies following transhumeral osseointegraion.

These applications include routing control cables in body-powered systems in the absence of a traditional socket (Figure 9, top) and harvesting myoelectric signals from the residual limb and routing those signals to the electric prosthesis in the absence of a socket interface (Figure 9, bottom). This content was presented to an international conference focused on upper-limb prosthetic rehabilitation (Monroe & Stevens, 2024a) and a subsequent international conference focused on osseointegration (Monroe & Stevens, 2024b).

Contributing to Consensus

In addition to the effort described above, members of the Institute were invited to participate in a structured consensus effort lead by Eric J. Earley, PhD and Jason W. Stoneback, MD with the University of Colorado Bone-Anchored Limb Research Group.

Using the Delphi consensus methods, an international panel of experienced prosthetists, therapists and physicians engaged in a series of survey rounds to establish consensus for the prescription of prosthetic components for bone-anchored prostheses at the transfemoral and transtibial amputation levels. These findings are also slated for publication later this fall.

Control Strategies in Transhumeral Bone Anchored Prosthetics

Figure 9: Bone-Anchored Transhumeral Prosthetics require unique approaches to providing a control strategy for the user. This includes the creation of anchor points for body powered control cables and harvest myoelectric signals that route to the users prosthesis, both in the absence of a traditional socket.

Establishing the State of the Science

The leadership of the Hanger Institute continued its involvement in establishing a sound foundation for bone-anchored prosthetics. Vice President of Clinical Affairs, Phil Stevens, accepted the invitation to contribute to the multi-disciplinary State of the Science Conference on Bone-Anchored Prosthetics (Figure 10).

The event, funded by the American Academy of Orthotists and Prosthetists and the American Board for Certification in Prosthetics, Orthotics and Pedorthoics, gathered a diverse cohort of clinicians and scientists to consider the state of the science in bone-anchored devices. The findings of this effort were reported at the 2025 Annual Meeting and Scientific Symposium of the American Academy of Orthotists and Prosthetists (Kaluf et al., 2025) and will be published as a supplement to the Journal of Prosthetics and Orthotics later this year.

Presenting Findings of the State of the Science Exercise

Figure 10: Phil Stevens presents portions of the Academy's State of the Science findings on Bone-Anchored Prosthetics at the AAOP Annual Meeting and Scientific Symposium.

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Continued Efforts to Advance Clinical Outcomes for Individuals with Upper Limb Amputation

Having established the predictive value of bimanual function, activity and participation levels and pain interference on the well being of individuals with upper limb amputation, the Institute began to look at the longitudinal impacts of prosthesis receipt on these variables. We continue to share these findings in appropriate academic settings including international conferences and editorial articles in one of the fields peer-reviewed journals.

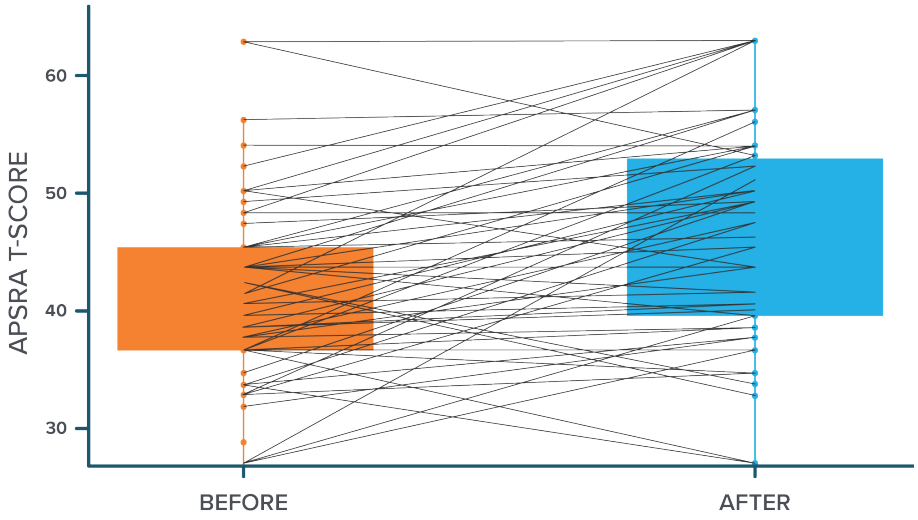
Measuring What Matters Most

The Institute continues to advance the collection of clinical outcomes for individuals with upper limb amputation. The focus of these outcomes is to better understand and ensure the benefit of appropriate prosthetic interventions for this population. This involves using patient-centered outcome measures like the PROMIS Ability to Participate in Social Roles and Activities (APSRA), which measures an individual's assessment of their activity and participation levels at home, work and within their community, and the PROMIS-9 Upper Extremity instrument (PROMIS-9), which evaluates an individual's perception of their bimanual function during daily activities. These measures have proven themselves useful in understanding and improving the quality of life for people who use an upper-limb prosthesis.

We previously reported that daily bimanual capacity (measured using the PROMIS-9), self-reported activity and participation levels (measured using the APSRA), satisfaction with an individual's prosthesis and the extent to which pain impacted daily activity were the strongest predictors of well-being among users of upper limb prostheses (Stevens et al., 2023). This study established the foundation for studying the effects of prosthesis receipt on one's perceived activity participation and pain interference.

Participation and Pain

Having established the importance of both activity and participation and pain interference to well-being in this population, we build upon pilot data shared in last year's report to determine whether the receipt of a prosthesis had any effect on an individual's ability to engage in home, work and community activities or the level of pain interference reported during daily tasks. These longitudinal relationships were first reported at the International MEC24 Symposium (England et al., 2024).

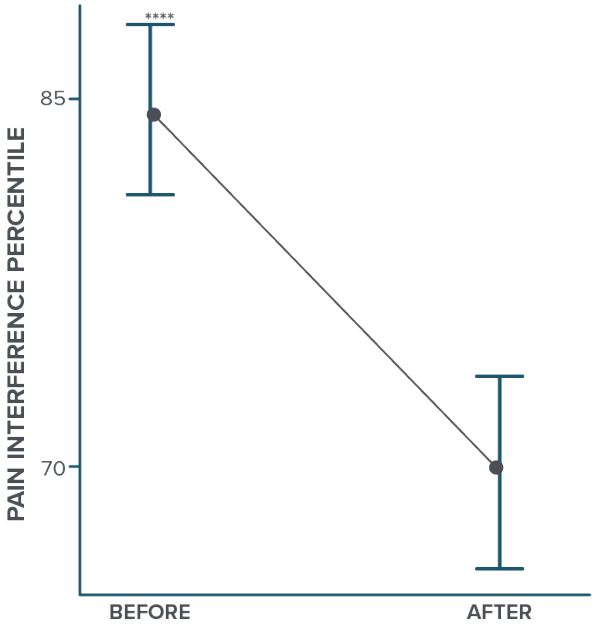


Activity and Participation Levels Before and After Receipt of a Prosthesis

Figure 11: Following the receipt of their prosthesis, users of upper limb amputation reported a significant improvement in their levels of activity and participation.

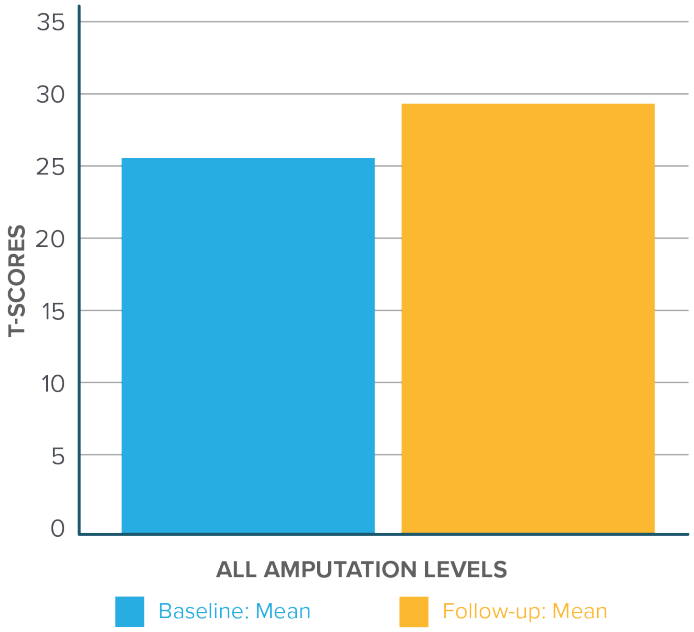
Results showed that the receipt of a prosthesis was associated with significant improvements in activity and participation levels (mean APSRA T-scores improving from 41.6 to 47.2; Figure 11) and reductions in pain interference (PI T-scores decreasing from 59.8 to 55.7). These changes remain significant after accounting for various confounding factors. These findings suggest that receiving a first prosthesis can

enhance physical function, reduce pain interference, and ultimately contribute to improved well-being and lifestyle participation for individuals with upper limb amputations. This analysis was subsequently presented at the American Orthotic and Prosthetic Association National Assembly in Charlotte, NC (Fylstra et al., 2024). There, we were able to reinforce the impact of prostheses on home and community participation, reporting upon our cohort of patients improving from 27th percentile in their mean APSRA scores prior to receiving a device, to the 39th percentile following receipt of their prosthesis. Additionally, the receipt of an individual's prosthesis was associated with a significant reduction in mean PI scores, from the 84th percentile to the 70th percentile for pain (Figure 12).



Pain Interference Values Before and After Receipt of a Prosthesis

Figure 12: Following the receipt of their prosthesis, individuals with upper limb loss or deficiency reported a significant decrease in their pain interference values, from the 84th percentile of the general population, to the 70th.



Bimanual Physical Function Before and After the Reciept of an Upper Limb Prosthesis

Figure 13: Longitudinal analysis confirmed that the receipt of a prosthesis was associated with a meaningful improvement in the bimanual physical function of individuals with upper limb loss or deficiency.

PROMIS-9 Responsiveness

In a recently published paper (Castleberry et al., 2025), we continued our longitudinal analyses by demonstrating the responsiveness of the PROMIS-9 Physical Function. This paper evaluated the effectiveness of the PROMIS-9 in detecting changes in bimanual functional capacity following prosthesis receipt in individuals with upper limb absence (Figure 13).

This study suggests the PROMIS-9 is a valuable tool for monitoring patient progress in upper limb prosthesis rehabilitation, capturing meaningful improvements in physical function. This study also underscores the instrument's clinical utility and supports its use in enhancing patient-centered care for individuals receiving a prosthesis.

Summarizing Insights for the Field

Recognizing the importance of enhancing the well-being of those individuals affected by upper limb loss, and the longitudinal benefits that have been observed with the receipt of a prosthesis, the Hanger Institute presented a Perspective Talk on these principles at the International MEC24 Symposium (Figure 14). This talk summarized our findings on the critical elements of activity, participation, bimanual function and pain interference and their relationship to a thoughtfully designed prosthesis coupled with appropriate training.

Measuring What Matters Most

Figure 14: Phil Stevens from the Hanger Institute provided at Perspective Talk at the MEC24 meeting summarizing the Institute's collective findings related to factors with the greatest contributions to well-being among individuals with upper limb loss or deficiency.

In addition, drawing from the findings of multiple studies authored and supported by members of the Hanger Institute, members of the Institute collaborated on the Editor's Comments for the April issue of the Journal of Prosthetics and Orthotics in which this multi-disciplinary team of a prosthetist and two occupational therapists addressed the importance of focusing prosthetic training on bimanual tasks that are of integral importance to the prosthesis user (Stevens et al., 2024).

This commentary was intended to supplant the legacy training models advocating for a foundation of training on unimanual engagement of the prosthesis, with bilateral activities deferred until the later stages of training. Recognizing the usage patterns of prostheses in the field and the relevance of bimanual activities and their relationship to activity and participation levels, the comments encouraged therapists to focus on bimanual activities from the initiation of prosthetic training.

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Integrating Patient Preferences into Clinical Decision Making

The Hanger Institute has been working diligently to help improve patient outcomes. This includes our recent efforts to enable shared decision making to help patients feel more involved and a part of their clinical care team.

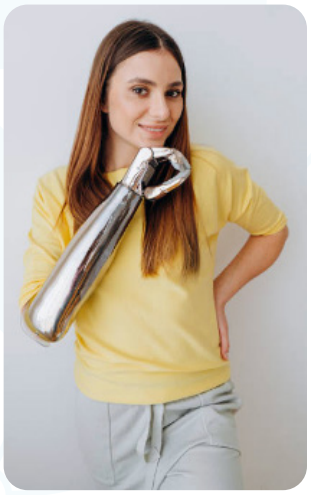
Shared Decision Making in Upper Limb Prosthesis Design

As part of this work, we have been working with the University of California San Francisco on a project entitled “Translating Outcomes that Matter Most to Individuals Living with Orthotics and Prosthetics into Shared Decision Making in the Practice Setting.” This project aims to address the decisions of some patients to discontinue their use of upper limb prosthetics despite advancements in technology. This research focuses on understanding patient preferences and the factors influencing their decisions when choosing prosthetic devices.

- Functional Usefulness of Device
- Device Weight, Comfort Experience
- Durability/Repair Times
- Amount of Concentration/Energy to use Device, even with Training
- Connection of Arm to Body
- Physical Training & Practice for Successful Use of Device
- Life Goals for Using Two Hands, Including Device
- Noticeability of Device

Discrete Choice Attributes for Upper Limb Prostheses

Figure 15: Working with our partners at the University of California San Francisco, we identified the attributes of greatest concern for individuals utilizing an upper limb prosthesis.



Discrete Choice Options for Noticability of the Device

Figure 16: As part of the discrete choice patient preference tool, patients were asked to grade their preferences relative to the noticeability of their device. Two options included a device that blends in and is less noticeable versus a device that expresses an individual’s personal style.

By developing a discrete choice patient preference tool, this study seeks to quantify the trade-offs between risks and benefits that individuals with upper limb loss consider important across the content areas listed in Figure 15. For example, subjects might rate their preferences on the noticeability of their prosthesis using the examples shown in Figure 16. The ultimate goal is to create a decision aid that can be used in clinical practice to enhance shared decision-making, improve patient satisfaction, and optimize prosthetic outcomes.

To date, this project has completed a thorough systematic literature review and the development of a discrete choice tool looking at a range of variables pertinent to upper limb prosthesis design. Various segments of this project have also been presented at the American Orthotic and Prosthetic Association (Wilson et al., 2024a), the American Academy of Orthotists and Prosthetists (Wilson et al., 2024b), and a recent publication in O&P Edge magazine (Nalivaika & Diaz Delgado, 2025). At this point, 250 individuals have completed the discrete choice questionnaire identifying what they perceived to be the most critical attributes of their prosthesis. The final decision aid is currently in development to help align a patient’s preferred attributes with a preferred set of devices, leading to a decrease in discontinued use.

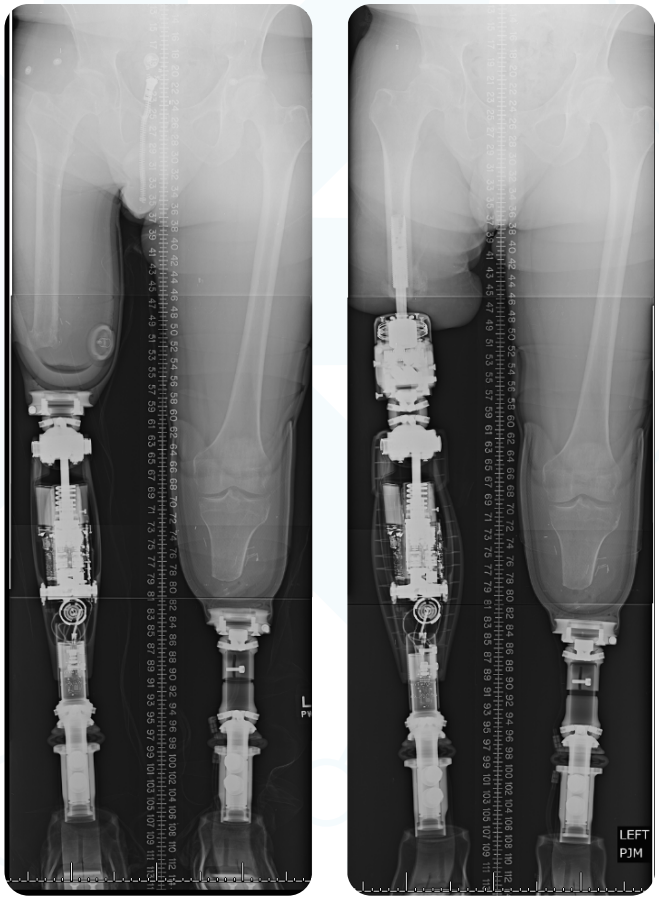
Collectively, these processes will inform the future design of prostheses that meet the needs and preferences of individuals with upper limb loss. They will also guide clinical trials by setting goals that focus on what matters most to patients. Additionally, the information may advocate for the approval of new prostheses and the expanded use of existing ones.

Informing the Decision to Pursue Bone-Anchored Prostheses

Shared decision making can also be applied to surgical techniques such as advancements in osseointegration. The Hanger Institute has partnered with the Duke University Preference Evaluation Research Group (PrefER) on an FDA-funded project to understand what information individuals need when deciding whether to pursue bone-anchored prostheses.

These prostheses may represent a significant improvement because they attach directly to the bone, potentially offering a better quality of life and improved mobility and prosthesis use. The study aims to develop a survey tool to ask individuals about their preferences and what evidence they find important when considering these new prostheses. It will collect data to gather information from individuals about what they need to know to feel comfortable using bone-anchored prostheses (Figure 17) and analyze preferences to understand which types of clinical evidence (like safety, effectiveness, etc.) are most important.

These projects highlight the Hanger Institute's commitment to integrating patient preferences into clinical decision-making, ultimately improving outcomes for individuals with limb loss.



Traditional Socket Transfemoral Prosthesis (left) and a bone-anchored prosthesis (right)

Figure 17: While the use of a bone-anchored prosthesis (right) has demonstrated a number of potential benefits, the rehabilitation field needs to determine what evidence is most important to patients considering this procedure.

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Enhancing Clinical Care through Artificial Intelligence

Artificial Intelligence is changing the landscape of healthcare and practice management. Within Hanger, we are turning to AI to provide solutions as clinicians seek to balance increased documentation requirements without sacrificing the ability to build and retain important relationships with patients. This is being done through ambient listening technologies, a referral note summary tool and the generation of synthesized clinical narratives. The dramatic increase in utilization of these tools across our national network of clinics is a testament to their utility and enhanced efficiencies.

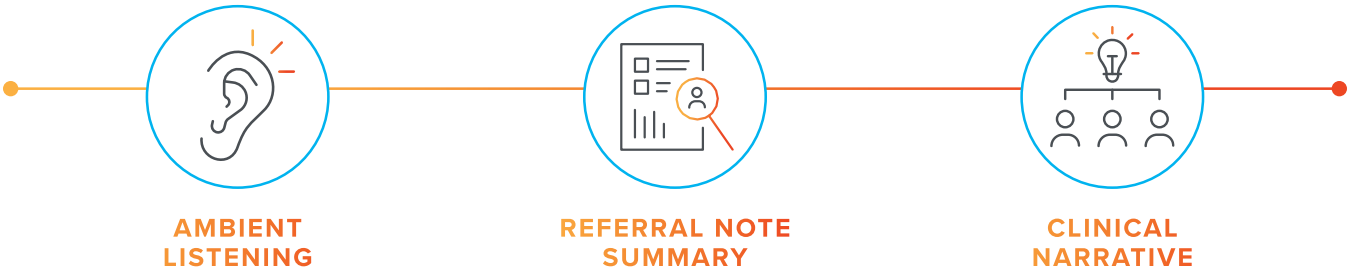
Clinical Assistant for Records Automation (C.A.R.A.)

Clinicians often face significant time constraints, balancing multiple patients, administrative duties, and treatment plans throughout their day. With so many demands on their time, a thorough review of each patient's entire medical record to ensure an aligned O&P treatment plan is untenable. An insufficient understanding of a patient's medical history can hinder the precision and personalization needed when designing a care plan. This can also create the risk that care may be designed based on limited or generalized data, rather than a holistic understanding of the patient's physical condition, lifestyle, and goals.

The challenge lies in the sheer volume of medical information that clinicians must process. A typical medical record contains a wealth of data, from clinical notes to imaging and lab results. Extracting the most relevant information needed for designing a personalized device that will best suit the patient's unique needs represents a common challenge.

In 2023, Hanger made the decision to invest in AI for more accurate and timely clinical documentation support. The Clinical Assistant for Records Automation (C.A.R.A.) AI tool was created to improve the lives of clinicians and patients by creating additional time and space for the formation of lifelong relationships, patient-centered collaboration and better health and mobility. An early critical choice was to build our own AI system that could be educated on prosthetic and orthotic care.

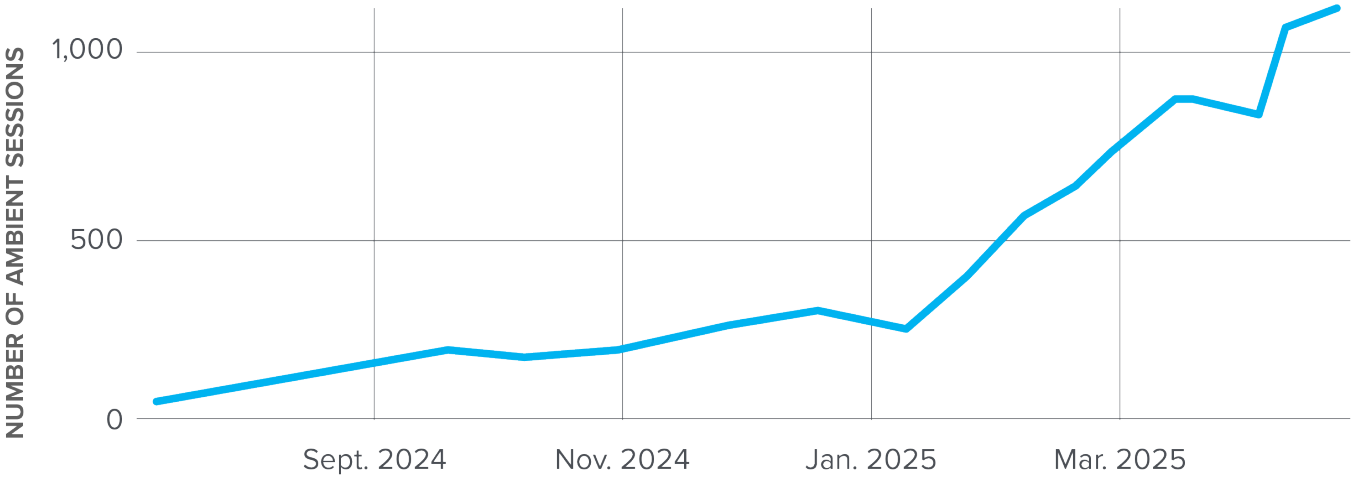
CARA AI consists of three elements:



Ambient listening allows clinicians and patients to have natural conversations without the clinician either being stuck behind the computer typing during the visit or forgetting to document a critical consideration. Additional features allow for short on-screen interview assistance to help ensure medical and functional necessity is supported in the final visit note. This part of CARA employs Generative AI, using the transcript of the visit conversation to write a unique summary of the relevant conversation segments. To further increase patient access, CARA has the ability to transcribe conversations in Spanish to create a summary of the visit in English.

Referral note summary uses Optical Character Recognition and custom prompts to screen the notes of other healthcare providers and summarize the content relevant to O&P care. This allows the clinician to readily use this information to guide their conversation with the patient and support both their documentation and clinical reasoning.

Clinical narrative utilizes generative AI trained specifically on O&P. This part of CARA AI combines the content gained from the referral note summary, elements obtained from the visit through ambient listening, and extraction of relevant information from the Electronic Health Record (EHR) template to create cohesive clinical narratives. This process pulls together medical information from previous doctor visits with current physical assessments and patient interviews conducted by clinicians. This content is then assimilated into an initial draft version for clinicians to review and refine. Clinicians can also interact with CARA clinical narrative to ask questions or refine the copy, making it a collaborative writing partner for producing detailed notes that would otherwise be both time-consuming and underinformed by the patient's medical history.



Clinical Adoptions of CARA Resources

Figure 18: The increasing number of Ambient Listening sessions over time suggests strong adoption of CARA resources in the clinic setting.

Hanger clinicians continue to experiment with how to best integrate CARA into their clinical practices. Adoption of the technology has seen a steady increase since its initial rollout after piloting it in select areas (Figure 18). Feedback from clinicians about patient care results when using CARA includes some of the following:

- *"I [had] an entire conversation in Spanish with very traditional Spanish lingo and it did an excellent summary."*
- *"As someone who has struggled with timely documentation, I am really enjoying using this. Thank you to the teams that have put this together and led it."*
- *"The AI ambient allowed us to look at the patient, listen, and be present, rather than looking down at our laptop trying to self-caputre and scribe everything going on. [That] is the absolute most important thing that came of it."*

For Hanger, CARA will always be a work in progress with iterative improvements. Our CARA AI mission statement is to empower clinicians by streamlining documentation workflows and harnessing EHR-based longitudinal data trends to improve health outcomes for patients using prostheses and orthoses. By reducing administrative burdens, we are enabling more meaningful patient-clinician relationships and fostering shared decision making, leading to better care through more face-to-face interactions. Ultimately, this results in notes that not only enhance clinical care but also meet the needs of insurance companies and other payers.

Contributing to the Conversations within Global Education

Every other year the International Society for Prosthetics and Orthotics hosts the Global Educators Meeting. Recognizing the diverse global locations for this meeting, and it's first occurrence in North America, the Hanger Institute was pleased to contribute to the Scientific Content of the Meeting. This was done via participation in several organized sessions and free paper presentation.

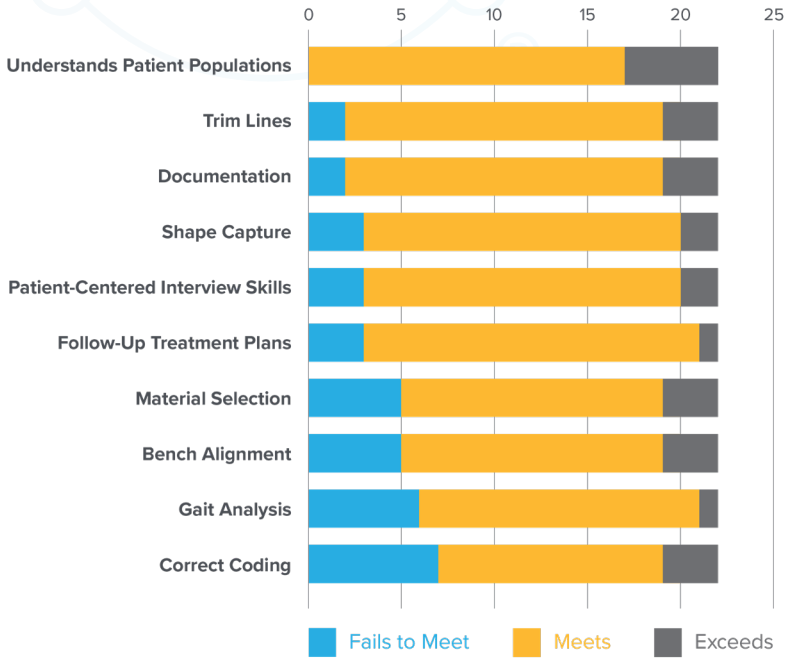
Retaining Clinical Talent in the Field

Partnering with a clinical program director and an early-stage clinician, Institute participation in this session addressed the growing concern of workforce shortages in Orthotic and Prosthetic care (Mullen et al., 2024). In addition to the reality that O&P educational programs are not consistently filling their seats, anecdotal reports suggest concerningly high attrition rates among early-career clinicians. Speaking to the employer's perspective, members of the Institute shared the practical importance of identifying student candidates that can adapt to change, manage stress, solve problems, communicate and blend didactic thinking with hand skills.

Students should also be prepared for the practical realities of on-call care and the relationships between competency, productivity and financial growth. Resources such as structured onboarding processes, peer liaisons, and board-preparation materials were suggested during the residency transition. However, resources for continued focused clinical learning and development as well as participation in professional networks can continue to provide direction and support during early career growth. Exposing students and residents to the principles of appropriate delegation within the clinic setting represents another skillset in managing and defraying the stresses of full-time clinical practice.

Preparedness of Incoming Residents

Given Hanger Clinic's position as the largest employer of O&P residents, the Institute conducted a survey of our most experienced residency mentors to assess how prepared current residents are relative to mentor expectations (Wening et al., 2024). Thirty mentors from across the country with at least five years of mentorship experience reported upon their observations. Our results indicate that while current graduates are generally meeting expectations in areas like professional awareness and documentation skills, some are falling short of expectations in more practical skills such as bench alignment, observational gait analysis and coding (Figure 19). We hope that these findings will support current efforts to better align educational curricula with the practical needs of residency.

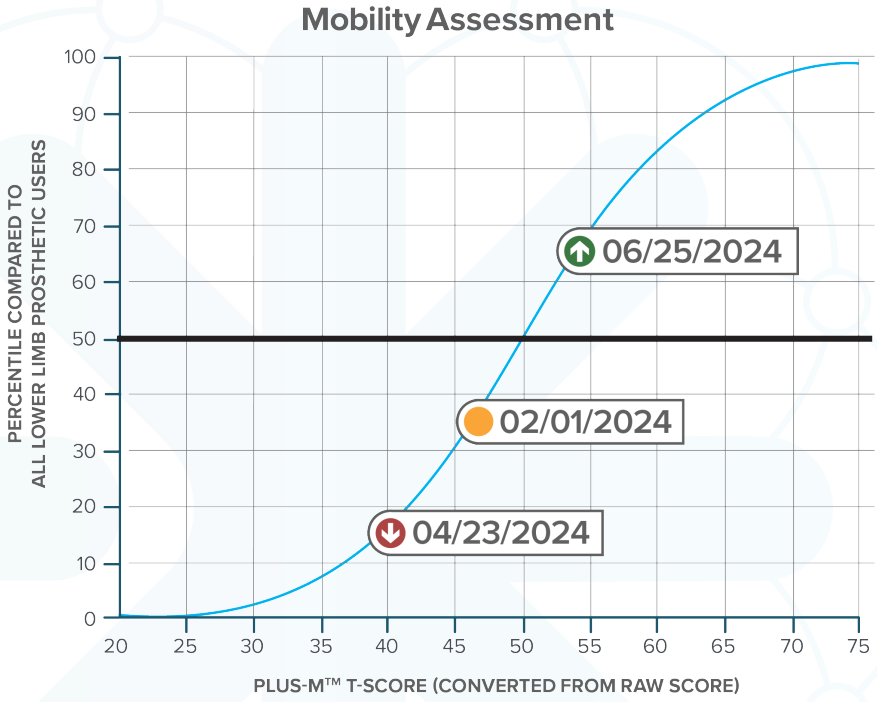


Proficiencies Observed Among Incoming Residents

Figure 19: Residents entering clinical practice were found to have areas of strength and areas of potential imporovement.

Mobility and Beyond

After years of collecting and analyzing prosthetic mobility data, the Institute aggregated their collective findings to help educators appreciate the expanding relationship between mobility and a number of different constructs in prosthetic rehabilitation (Stevens, 2024). These include the positive correlation between prosthetic mobility and quality of life, and the role of mobility in predicting an individual's fall risk. Additionally, prosthetic mobility data has been used to document the increased functionality experienced with various knee and foot technologies.



Tracking Prosthetic Mobility Over Time

Figure 20: The regular collection of prosthetic mobility outcomes allows clinicians to help patient set mobility goals and track their mobility over time.

Aggregating mobility data over large populations has facilitated the development of mobility curves. Similar to pediatric growth curves, these curves allow the prediction of expected mobility based on considerations such as age, amputation level and etiology, and sex. When properly utilized, this knowledge can provide individual prosthesis users with context for their rehabilitation, informing reasonable goals and tracking progress over time (Figure 20).

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Hanger LIVE 2025: Transforming the Future of O&P Patient Care

The annual Hanger LIVE conference took place from January 27–30, 2025 at the Gaylord Opryland Resort in Nashville, TN, bringing together over 1,600 Hanger employees, exhibitors, speakers, and industry experts. This year's theme, "Future FWD," highlighted Hanger's commitment to creating an ecosystem that will revolutionize orthotic and prosthetic (O&P) patient care and the profession as a whole.

Kicking Off with the Global Partners Summit

The impactful week began with the first-ever Global Partners Summit, welcoming more than 150 thought leaders from O&P manufacturers, independent providers, educational institutions, and professional associations, along with O&P students and therapy partners in care. Topics addressed during our O&P Professionals track for the event included:

- **AI in Healthcare: Enhancing the Experience for our People, Patients and Partners** where we explored how artificial intelligence is transforming orthotics and prosthetics and making care more efficient, adaptive and responsive to individual needs of our patients.
- **State of the Profession: Innovation and Progress in O&P** that engaged with CEOs from across the O&P industry to explore opportunities for collaboration, uncovering shared goals and streamlining care delivery for the populations we serve.
- **Mobility and Beyond: Future and Focus of the Hanger Institute** focused on sharing insights on the work and our commitment to driving the future of patient-centered solutions through data-driven insights.

Hanger Chief Executive Officer Pete Stoy emphasized the importance of collaboration, stating, “Hanger LIVE provided the perfect setting to bring together our valued O&P partners to connect, collaborate, and drive progress within our profession.”

> “I’m excited to see the industry coming together and addressing some of the most critical strategic challenges.”
>
> **–GPS ATTENDEE**

A Wealth of Educational Opportunities

Over the course of four days, attendees had the opportunity to participate in 120 courses taught by 75 experts from across the country. The sessions covered a wide range of topics, including cranial care, patient advocacy and policy change, outcome measures, and 3D printing.

This year's clinical keynote session was delivered by Dr. Robert Sallis, Director of Sports Medicine Fellowship at Kaiser Permanente, along with experts from the Hanger Institute for Clinical Research & Education. Dr. Sallis highlighted the significance of integrating fitness and movement into healthcare, while the Institute team shared insights on how emerging technologies are enabling safe movement and increased fitness across the populations serviced in our O&P clinics.

These were followed by three discipline-specific symposia. In lower limb prosthetics, the content was focused on ways to enhance the quality and consistency of care provided to individuals with transfemoral amputations ambulating at a limited-household level (e.g., K2 ambulators). These included considerations and candidacy for microprocessor knees, comprehensive documentation, thoughtful socket design, the consistent collection of outcomes across a range of knee and foot options and consistent engagement of physical therapy.

The lower limb orthotist content focused on the appropriate integration of novel treatment options into orthotic care. This included guidance on the integration of microprocessor KAFOs and the merging of additive manufacture with poster carbon strut in modular AFO systems. For those focusing on pediatric care, the symposium focused on issues of body acceptance, resilience and fostering a positive self-image.

These symposia were then followed by our annual Grand Round event, where 32 clinicians presented individual case studies in four concurrent sessions dedicated to lower limb prosthetics, upper limb prosthetics, adult lower limb orthotics and pediatrics. Clinicians continued to contribute to the educational content throughout the balance of the week, with more than 80 clinical professionals providing some level of instruction to their peers.

Contributions to Knowledge Translation with the Rehabilitation Community

The Institute remains committed to disseminating relevant educational content to our patients and our peers in related rehabilitation fields. This included our launch of Hanger Clinic University, a platform devoted to hosting global O&P education content, hosting our inaugural Global Partners Summit as part of Hanger LIVE, continuing our commitment to virtual education series in areas like patient advocacy, documentation of medical necessity and comprehensive approaches to clinical care and two successful iterations of our popular EmpowerFest patient events.

Empowering Progress Through Professional Education & Collaboration

At the core of our mission lies a commitment to translating clinical knowledge, building interdisciplinary partnerships, and driving progress through education. In the past year, the Institute took significant steps forward in fulfilling this mission through co-launching a transformative education platform, hosting cross-disciplinary events, and expanding access to knowledge across the continuum of care. Working alongside Hanger's Professional Education team, these efforts not only reinforced our culture of collaboration, but also ensured that all healthcare partners remain equipped to deliver evidence-based, patient-centered care in an evolving healthcare landscape.

Hanger Clinic University: Shaping the Future of O&P Education

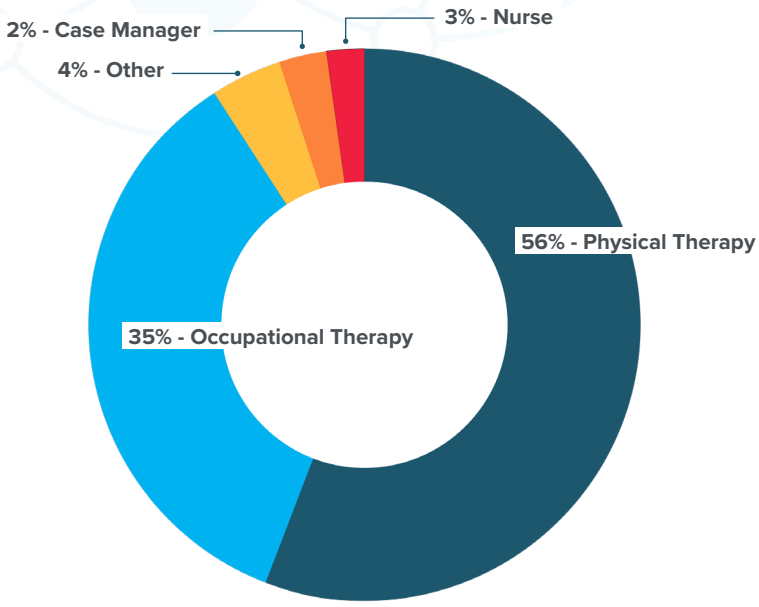
In 2024, we proudly partnered on the launch of **Hanger Clinic University**, a centralized hub designed to provide structured, accessible, and ongoing professional development for healthcare professionals worldwide. Through an innovative learning platform brought to you by Hanger Clinic, Hanger Clinic University equips healthcare providers with the cutting-edge knowledge and skills needed to drive better patient outcomes. Whether by engaging with foundational O&P knowledge or exploring advanced concepts, learners will be empowered to build skills at their own pace—reinforcing our commitment to lifelong learning and clinical excellence.

Key Outcomes

2,500+
learner registrations in first 6 months

Most-offered live, in-person classes:

- Overview of Lower Limb Prostheses
- Improving Transtibial Amputee Gait
- Ankle-Foot Orthoses & Postoperative Care



Multidisciplinary Participation within Hanger Clinic University

Figure 21: Over 2,500 learners from many disciplines accessed educational content through the new Hanger Clinic University platform.

Virtual Education Series: Expanding Access to Knowledge

The Hanger Institute Virtual Classroom Series continued to break down geographic and interdisciplinary barriers, connecting healthcare professionals around the world with expert-led discussions on timely clinical topics. This year's standout sessions focused on:

- **Journey to Policy: Unpacking Wins in Successful O&P Advocacy**
  In this session, researchers, advocacy leaders, and patients provided insights on effective advocacy strategies, the importance of building a robust body of evidence, and the value of a patient-centered collaborative approach to ensuring proposed policies are enacted.
- **Medical Necessity in Prosthetics and Orthotics: An Interdisciplinary Care Team Approach**
  This session helped participants better understand medical necessity related to prosthetics and orthotics, how it fits into physical rehabilitation, what type of medical record information can inform medical necessity for an expected health outcome after the provision of the prosthesis or orthosis, and how to come together to effectively document that information for better patient care.
- **Comprehensive Care of Plagiocephaly, Torticollis, and Early Childhood Development**
  Through evidence-based strategies, case studies, and hands-on guidance, therapists gained skills in identifying, assessing, and treating these conditions effectively.
- **Quantifying Sagittal Synostosis Presentation from Screening through Treatment**
  Participants gained insight into how innovative tools and measured outcomes are transforming care through enhanced diagnoses, treatment optimization, and collaborative decision-making.

> "This is great way to hear from leading professionals in our field. It gives you better insight on different topics for you to consider and to adapt into your practice."
> **–VIRTUAL EDUCATION SERIES ATTENDEE**

> "The virtual classroom is an effective way the [Institute] brings different disciplines together to discuss interdisciplinary approaches for solving patient challenges."
> **–VIRTUAL EDUCATION SERIES ATTENDEE**

> "Tons of education in every presentation. Knowledgeable presenters. Great and relevant topics."
> **–VIRTUAL EDUCATION SERIES ATTENDEE**

This series reached

500+ attendees across 4 sessions

ensuring that cutting-edge knowledge remains accessible and actionable for all providers.

EmpowerFest: Connecting with Medical Professionals

Our national EmpowerFest events continued to serve as a bridge between the O&P field and the broader medical community. These 3-5 hour sessions brought together physicians, surgeons, nurse practitioners, and therapists to deepen their understanding of limb loss care. In collaboration with our Hanger Clinic teams in Seattle, WA and Hollywood, FL, these events provided a dynamic launching point for learning, offering both new and advanced level therapists insights, practical tools and interdisciplinary perspectives to enhance their care for individuals living with limb loss.

Each event featured live demonstrations, patient perspectives, and collaborative hands-on sessions, creating a 360-degree view of patient care from diagnosis through rehabilitation.

CONNECTING PEOPLE WITH
EMPOWERFEST 2025
UPPER & LOWER LIMB LOSS

Looking Ahead

As we continue building on these achievements, we remain focused on creating dynamic, accessible, and transformative educational experiences. Whether virtual, on-demand, or in the classroom, our goal is clear: to foster knowledge-sharing that ultimately enhances patient lives.

Hanger Institute's 2024-25 Conference Participation

The Institute collaborated with a number of professional educational conferences to share our research findings with our physician, therapist, orthotist, and prosthetist colleagues.

This year, Institute speakers were able to support the educational conferences of the American Academy of Orthotists and Prosthetists and the American Orthotic and Prosthetic Association, the Global Educators Meeting of the International Society of Prosthetics and Orthotics, the Global Consensus Conference on Osseointegration, and the Myoelectric Controls Symposium. Below is an overview of the different conferences and sessions.

American Academy of Orthotists & Prosthetists (AAOP) 51st Annual Meeting and Scientific Symposium

Atlanta, GA | Feb. 26-March 1, 2025

- Hands-On Workshop: Fundamentals of MPKAFO, Proficiency, Programming, Casting, and Alignment (Weber, E., Friedman, T., McGee, M., and McCoy, M.)
- Fall Risk Among the Elderly: Assessment Below and Above the Ankle (Stevens, P.)
- Findings of the Academy's State of the Science Conference on "Prosthetic Care Following Osseointegration Surgery" (Kaluf, B. and Stevens, P.)
- Management of Phantom Limb Pain (Johnson, K., Rich, T., Sillies, L., and Worthing, R.)
- Changing O&P Policy: How Evidence Drives Policy Change (Fylstra, B., Baumer, M., Sachs, S., and White, A.)
- Shaping Health Disparities Research in Orthotics and Prosthetics (McDonal, C., Cave, J., Rhett, A., Clemens, S., Fylstra, B., and Walker, N.)
- Subischial Socket Technology: Challenging Cases, Clinical Indications, and Current Research (Caldwell, R., Fatone, S., and Kilpatric, C.)
- Leveling Up Your Physical Exam: O&P Decision-Making and Communication (Mullen, A., Kenworthy, S., and Parente, M.)
- Upper Limb Prosthetics – Past, Present, and Future of Upper Limb Prosthetic Care (Castleberry, T., Miller, L., Todd, A., and Wilson, L.)
- Development of a Microprocessor KAFO Patient Care Protocol (Carroll, K., Toelle, C., and McCoy, M.)
- Patient Reported Outcomes Following Lower Limb Socket and Prosthesis Replacement (Castleberry, T.)

Global Consensus Conference (GCCO) on Osseointegration

Charlotte, NC | November 2-3, 2024

- Findings of the Academy's State of the Science Conference on "Prosthetic Care Following Osseointegration Surgery" (Kaluf, B. and Stevens, P.)
- Variations in Control Strategy Following Transhumeral Osseointegration (Monroe, B. and Stevens, P.)

4th ISPO Global Educators Meeting (GEM)

Houston, TX | October 22-24, 2024

- Career Clinician: How Educators and Industry Can Work to Improve Retention and Talent (Mullen, A., Krische, G., Gosschalk, E., and Stevens, P.)
- The Benefits of Partnership Between Industry and Educational Institutions (Cochrane, H. and Reber, D.)
- O&P Graduates' Preparedness for Residency: Perceptions of Mentors (Wening, J., Hagemeier, K., Robinson, C., Swiley, V., Reber, D., and Stevens, P.)
- Mobility and Beyond: Findings and Future Focus of the Hanger Institute (Stevens, P.)

GEM Group Photo | Credit: Baylor College of Medicine

American Orthotic & Prosthetic Association (AOPA) National Assembly

Charlotte, NC | September 12-15, 2024

- Osseointegration for Amputation Reconstruction: Clinical Applications and Continuing Care (Elgard, M.)
- Modern Patient Preference Technologies to Drive Patient Outcomes Within Prosthetic Choice (Castleberry, T., Stark, G., White, A., Wilson, L., and Wurdeman, S.)
- Responsiveness of PROMIS-9 UE Physical Function to Prosthesis Rehabilitation (Castleberry, T.)
- Prosthesis Receipt Is Associated with Improved Participation and Decreased Pain Following Upper Limb Amputation (Fylstra, B.)
- Assessing Outcomes with Microprocessor Knee Utilization in a K2 Population (ASCENT K2): Findings from a Clinical Trial of 107 Individuals with Above-knee Amputation (Kannenberg, A. and Wurdeman, S.)
- Response Probabilities of PLUS-M Scores for Individuals with Lower Limb Amputation (Fylstra, B.)
- MPK K2: Benefits and Reimbursement Update (Dobson, A., Hahn, A., Kannenberg, A., and Wurdeman, B.)
- Early Prosthesis Receipt Is Associated with Better Odds of Employment After Lower Limb Amputation (Wurdeman, S.)

MEC24 Symposium

New Brunswick, Canada | August 12-15, 2024

- Measuring What Matters Most in Upper Limb Prosthetic Rehabilitation: Perspective Talk (Stevens, P.)
- Prosthesis Receipt Is Associated with Improved Participation and Decreased Pain Following Upper Limb Amputation (England, D., Fylstra, B., Castleberry, T., Stevens, P., and Wurdeman, S.)
- Preliminary Evaluation of Variations in Control Strategy Following Transhumeral Amputation (Monroe, B. and Stevens, P.)
- Integrating Novel Components Into Bilateral Pediatric Shoulder Disarticulation Prosthetic Fitting: A Case Study (Curcio, B.)

Peer-Reviewed Publications

Lower Limb Orthotics

- Balkman, G., Bamer, A., Stevens, P., Weber, E., Morgan, S., Salem, R., Amtmann, D., & Hafner, B. (2023). Development and initial validation of the Orthotic Patient-Reported Outcomes-Mobility (OPRO-M): An item bank for evaluating mobility of people who use lower-limb orthoses. *PLoS ONE*, 18(11), e0293848.
- Balkman, G., Hafner, B., Bamer, A., Salem, R., Morgan, S., Stevens, P., & Weber, E. (2025). Evaluating patient-reported health outcome profiles of lower limb orthosis users. *Disability and Rehabilitation*, 46, 1–9.
- Highsmith, M., Miro, R., Kartel, M., Ramrattan, A., Courtade, A., Heckman, J., Phillips, S., Wurdeman, S., DiBello, T., England, D., Stevens, P., Campbell, J., Hyre, M., Maikos, J., Hill, O., & Carey, S. (2024). Functional and perceptive differences between conventional and advanced ankle-foot orthoses in community ambulators post-limb trauma: The injuries managed with advanced bracing of the lower extremity (IM ABLE) study. *Frontiers in Rehabilitation Sciences*, 5, Article 1277509.
- Ruetz, A., DiBello, T., Toelle, C., Hemmen, B., Wening, J., Weber, E., Braatz, F., Winkler, T., Steinfeldt, F., Umari, M., Rupp, R., Kluge, S., Krebs, A., & Wurdeman, S. (2024). A microprocessor stance and swing control orthosis improves balance, risk of falling, mobility, function, and quality of life of individuals dependent on a knee-ankle-foot orthosis for ambulation. *Disability and Rehabilitation*, 46(17), 4019–4032.
- Stevens, P., Hafner, B., Weber, E., Morgan, S., Bamer, A., Salem, R., & Balkman, G. (2024). Utilization of orthoses and assistive devices among a national sample of lower limb orthosis users. *Journal of Rehabilitation and Assistive Technologies Engineering*, 11, Article 20556683241260891.

Lower Limb Prosthetics

- Fylstra, B., England, D., Stevens, P., Campbell, J., & Wurdeman, S. (2024). Creating Adjusted Scores Targeting mobiLity Empowerment (CASTLE 1): Determination of normative mobility scores after lower limb amputation for each year of adulthood. *Disability and Rehabilitation*, 46(9), 1904–1910.
- Kannenberg, A., Rupp, R., Wurdeman, S., & Frossard, L. (2024). Editorial: Advances in technology-assisted rehabilitation. *Frontiers in Rehabilitation Sciences*, 5, Article 1465671.

Upper Limb Prosthetics

- Castleberry, T., England, D., Fylstra, B., Stevens, P., Todd, A., Mandacina, S., & Wurdeman, S. (2025). PROMIS-9 UE physical function demonstrates moderate responsiveness for patients following upper limb prosthesis intervention. *Journal of Patient-Reported Outcomes*.
- Resnik, L., Borgia, M., Heinemann, A., Stevens, P., Clark, M., & Ni, P. (2023). The Upper Extremity Functional Scale for Prosthesis Users (UEFS-P): Subscales for one- and two-handed tasks. *Disability and Rehabilitation*, 45(22), 3768–3778.
- Serbin, R., Loeffler, B., Frix, J., Gachigi, K., Todd, A., Monroe, B., Stevens, P., Emmrich, L., McGuinness, D., & Gaston, R. (2025). Enhancing prosthetic outcomes in partial hand amputees: A case series on the starfish procedure and four-site myoelectric prostheses. *Journal of Prosthetics and Orthotics*. (Accepted, pending publication).
- Stevens, P., England, D., Todd, A., Mandacina, S., & Wurdeman, S. (2023). Activity and participation, bimanual function, and prosthesis satisfaction are strong predictors of general well-being among upper limb prosthesis users. *Archives of Rehabilitation Research and Clinical Translation*, 5(2), 100264.
- Stevens, P., Todd, A., & Dunbar, K. (2024). Editor's comments: Informing upper-limb prosthetics training practice and priorities with recent evidence. *Journal of Prosthetics and Orthotics*, 36(4), 215–216.
- Wilson, L., Gutin, M., Banh, T., Gress, E., Castleberry, T., Asatkar, S., Tahir, P., Douglas, M., & Wurdeman, S. (2025). Outcomes and preferences for decision-making for upper limb prosthetic care: The patient journey—A systematic literature review. *Archives of Rehabilitation Research and Clinical Translation.*

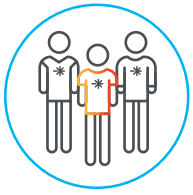
Cranial Orthotics

- Ramsey, J., Stevens, P., Coats, B., Dixon, T., Chaker, S., Bonfield, C., & Golinko, M. (2025). Comprehensive craniometry for sagittal synostosis. *Neurosurgical Focus—Journal of Neurosurgery*, 58(1), E8.

Hanger Clinic O&P Residency Program

Since 1996, the Hanger Clinic O&P Residency Program has trained more than 950 O&P residents. Our investment in the next generation of clinical experts is unparalleled, ensuring that patients across the country have access to care delivered with empathy and expertise for years to come.

The Hanger Clinic O&P Residency Program recruits students from across the nation's Orthotic and Prosthetic Programs as it helps prepare new graduates for competent, autonomous clinical practice in the field of O&P (Figure 21). We utilize a comprehensive, gradual experiential model within a broad-based professional and academic environment conducive to the education and training of tomorrow's industry leaders.



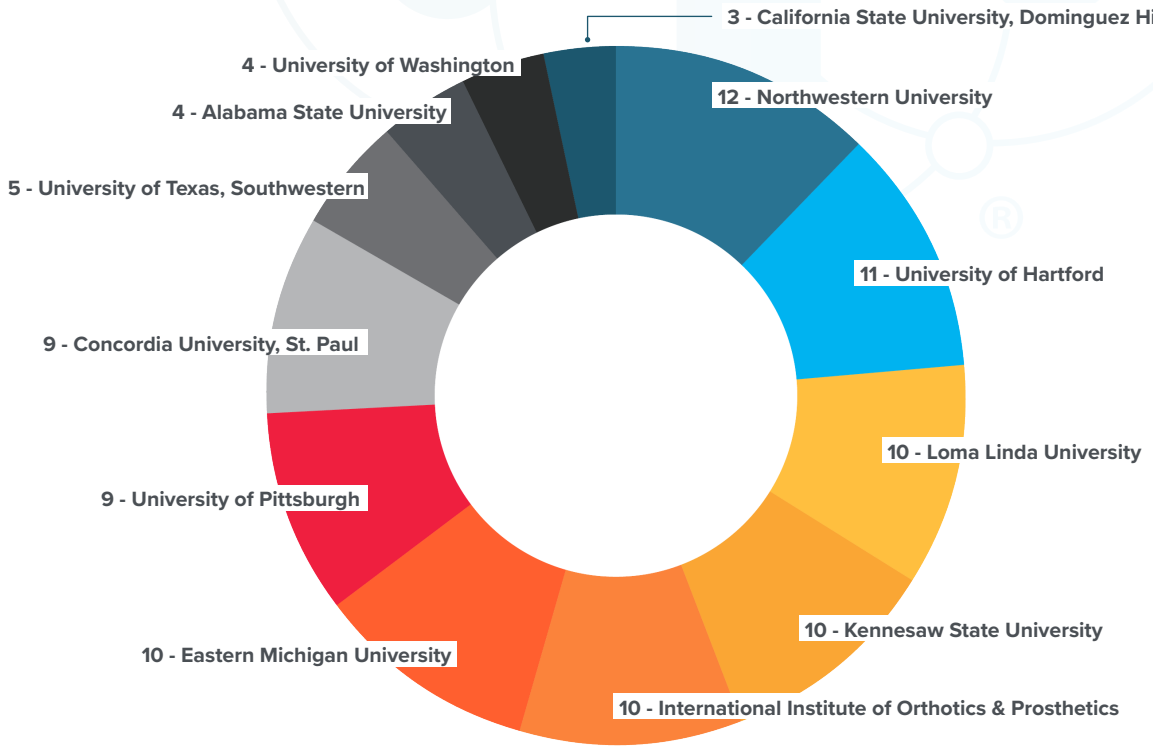
In 2024, Hanger Clinic hired 96 new residents.

For training, 43 residents selected the 12-month option and 53 selected the 18-month combined option.

We offer comprehensive, patient-oriented resident training environments that focus on the development of new clinicians. We provide elevated educational opportunities and requirements above and beyond the standards of NCOPE, our resident credentialing board. Hanger Clinic residents are asked to perform advanced activities, including viewing surgeries and participating in advanced evaluation clinics for our patients.

In 2024, Hanger Clinic hired 96 new residents from 12 orthotic and prosthetic educational programs (Figure 22). For training, 43 residents selected the 12-month option and 53 selected the 18-month combined option. Residents also participate in our mock exam process that is held three times per year. Both prosthetic and orthotic board-eligible clinicians attend, where they participate in mock situations to prepare them for their board exams. This process results in Hanger Clinic residents passing the board exam at levels higher than industry averages.

The Hanger Clinic O&P Residency Program has a management structure that allows continuous check-ins by national and regional leaders (resident liaisons). Each year, Hanger Clinic trains approximately 150 residents as they move through the 12-month or 18-month options of training, most of whom stay with the organization to continue their professional development.



O&P Schools preparing the latest class of Hanger Clinic Residents

Figure 22: In 2024-2025, Hanger Clinic hired 96 new residents from 12 O&P education programs.

Who We Are:
Meet the Institute Teams

The Hanger Institute is fortunate to have access to a number of motivated and talented professionals. These include internal Hanger Associates who oversee its day-to-day operations and Hanger Affiliates who support a number of Institute initiatives in addition to their primary responsibilities within Hanger Clinic and other segments of Hanger, Inc. In addition, the Institute is engaged in a number of research collaborations with Academic Partners as well as research and development projects with Industry Collaborators.

Leadership & Associates

The core faculty of the Hanger Institute is comprised of a team of dedicated professionals in their disciplines of clinical care, research, and education.

Shane Wurdeman, PhD, CP, FAAOP(D)
Chief Clinical Officer

Phil Stevens, MEd, CPO/FAAOP
Vice President of Clinical Affairs

James H. Campbell, PhD
President, Hanger Ventures

Kathleen Carroll, MS, MSPO, CPO, FAAOP
Outcomes Program Specialist

Todd Castleberry, PhD
Research Scientist

DeAnna Chapman, CPO, FAAOP
Director of Operations

Tom DiBello, L/CO, FAAOP
Director, Clinical & Scientific Affairs

Patsy Diaz Delgado, MS
Research Associate

Dwiesha England, MSEng
Research Associate

Bretta Fylstra, PhD
Research Scientist

Jasmine Khan, MPH
Research Associate

Liliana Komraus, MS
Director, Partner Professional Education

Stephen Mandacina, CP
National Director Upper Limb Program

Molly McCoy, CPO
Clinical Documentation Specialist

Kristin Nalivaika, OTD, OTR/L
Research Associate II

Erin O'Brien, CPO, FAAOP
Clinician & Clinical Education Specialist

Shannon O'Shea, CPO
Area Clinic Manager & National Clinical Specialist, Pediatrics

Matthew Parente, MS, PT, CPO, FAAOP
Clinical Education Specialist

Doug Reber, L/CO
Director, Education & National Residency

Emily Steffensen, PhD, CPO
Clinical Research Scientist

Chris Toelle, CO
Clinical Specialist Orthotics

Eric Weber, CPO, FAAOP
Clinician & Clinical Research Associate

External Advisory Board

To provide guidance around our mission to explore, expand, and facilitate opportunities that help advance leading-edge research, evidence-based care, and quality education in O&P, the Hanger Institute formed an external Advisory Board composed of highly respected, experienced members of the healthcare community.

Judith M. Burnfield, PhD, PT
Director, Institute for Rehabilitation Science and Engineering
Director, Movement and Neurosciences Center
Clifton Chair, Physical Therapy and Movement Sciences
Madonna Rehabilitation Hospitals | Lincoln, NE

Alan Davis, MD
Emeritus Staff, The Cleveland Clinic
Wright State University Boonshoft School of Medicine | Fairborn, OH

Catrine Tudor-Locke, PhD, FACSM, FNAK
Dean, College of Health and Human Services
Professor, College of Health and Human Services
University of North Carolina | Charlotte, NC

Ashley Mullen, PhD, MSAT, CPO
Associate Professor, Program Director, School of Health Professions Orthotics & Prosthetics Program
Baylor College of Medicine | Houston, TX

Ashlie White, MA
Chief Strategy & Programs Officer, Amputee Coalition

Academic Partners

Collaborative research remains a core activity of the Hanger Institute, with team members pursuing patient-centered research questions across a broad spectrum of patient populations and interests. Several of our partners in such efforts include:

Center for Adaptive Systems of Brain-Body Interactions
George Mason University

Department of Medicine
University of California San Francisco

Department of Physical Therapy
Virginia Commonwealth University

Department of Physical Therapy and Rehabilitation Science
The University of Iowa

Department of Population Health Sciences
Duke University School of Medicine

Department of Rehabilitation Medicine
University of Washington

School of Biological and Health Systems Engineering
Arizona State University

Walker Department of Mechanical Engineering
The University of Texas at Austin

Department of Health Sciences and Research, College of Health Professions
Medical University of South Carolina

External Grant Funding

As the Hanger Institute and its collaborators continue to pursue our diverse and ongoing research efforts, we acknowledge and thank the associated funding mechanisms and sources that support our activity through various research grant awards. These entities include:

Department of Defense – Congressionally Directed Medical Research Programs
National Institutes of Health
National Institute on Disability, Independent Living, and Rehabilitation Research
US Department of Veterans Affairs
Center for Orthotic and Prosthetic Learning

Evidence Update: Benefits of Orthotic & Prosthetic Care

The benefits of lower limb orthoses are being increasingly recognized. These include clear benefits of microprocessor orthoses and posterior strutted orthoses relative to more traditional devices. Utilization patterns suggest the importance of devices designed for use in outdoor community settings, activities and environments that are well-assessed using the recently validated OPRO-M outcomes instrument. Newly developed prosthetic mobility curves allow for individualized goal setting. These curves appear to be positively impacted by appropriate component selection. Among upper limb amputees, several predictors of positive well-being have been identified. Several of these have been found to improve with the receipt of upper limb prostheses.

Key Findings

- When managed with a microprocessor knee-ankle-foot-orthosis, legacy users of traditional knee-ankle-foot-orthoses realize significant improvements in their static and dynamic balance with reduced falls and fall risk (Ruetz et al., 2024).
- Individuals fitted with posterior strutted AFOs report fewer mobility problems and less perceived exertion relative to that associated with more traditional AFO designs (Highsmith et al., 2024).
- While orthosis use is less frequently reported during activities that involve short walking distances in the home, at least 80% of lower limb orthosis users report using their devices during the performance of community-based activities (Stevens et al., 2024).
- The 12- and 20-item versions of the newly developed Orthotic Patient Reported Outcomes – Mobility (OPRO-M) are strongly correlated with existing patient-reported outcomes and successfully differentiate between groups with expected mobility differences (Balkman et al., 2023).
- Age-based mobility curves for individuals with transfemoral amputation due to both vascular and traumatic etiologies demonstrate increased prosthetic mobility with the use of microprocessor knee joints (Fylstra et al., 2024).
- Bimanual physical function, activity and participation levels, prosthesis satisfaction and low levels of pain interference are significant predictors of enhanced well-being among individuals with upper limb amputation or deficiency (Stevens et al., 2023).
- Following prosthesis receipt, individuals with upper limb amputation and limb deficiency realize significant improvement in their bimanual upper limb physical function (Castleberry et al., 2025).
- Individuals with unilateral upper limb amputation utilize their prostheses more in bilateral tasks than unilateral tasks. By contrast, those with bilateral upper limb amputation utilize their prostheses more during unilateral activities than bilateral activities (Resnik et al., 2023).

SCAN TO VIEW OUR PUBLISHED RESEARCH

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- Balkman, G., Bamer, A., Stevens, P., Weber, E., Morgan, S., Salem, R., Amtmann, D., & Hafner, B. (2023). Development and initial validation of the Orthotic Patient-Reported Outcomes-Mobility (OPRO-M): An item bank for evaluating mobility of people who use lower-limb orthoses. *PLoS ONE*, 18(11), e0293848.
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- Fylstra, B., England, D., Stevens, P., Campbell, J., & Wurdeman, S. (2024). Creating Adjusted Scores Targeting mobiLity Empowerment (CASTLE 1): Determination of normative mobility scores after lower limb amputation for each year of adulthood. *Disability and Rehabilitation*, 46(9), 1904–1910.
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- Ruetz, A., DiBello, T., Toelle, C., Hemmen, B., Wening, J., Weber, E., Braatz, F., Winkler, T., Steinfeldt, F., Umari, M., Rupp, R., Kluge, S., Krebs, A., & Wurdeman, S. (2024). A microprocessor stance and swing control orthosis improves balance, risk of falling, mobility, function, and quality of life of individuals dependent on a knee-ankle-foot orthosis for ambulation. *Disability and Rehabilitation*, 46(17), 4019–4032.
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- Stevens, P., Hafner, B., Weber, E., Morgan, S., Bamer, A., Salem, R., & Balkman, G. (2024). Utilization of orthoses and assistive devices among a national sample of lower limb orthosis users. *Journal of Rehabilitation and Assistive Technologies Engineering*, 11, Article 20556683241260891.

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