



Embodiment and Identity Reconstruction among Neural Prosthetic Limb Users

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ABSTRACT

Advancements in biomedical engineering have transformed the interface between humans and technology, particularly through neural prosthetic systems that restore movement and sensation via direct neural integration. Within this rapidly evolving field, understanding how individuals experience and adapt to such technologies remains limited, especially regarding the emotional and existential dimensions of embodiment. However, despite extensive research on biomechanical performance and neural responsiveness, little is known about how users construct meaning, identity, and bodily perception after adopting neural prosthetics raising the question of how technological embodiment redefines selfhood and lived experience. Using an interpretative phenomenological approach (IPA), this study explores the subjective experiences of individuals living with neural prosthetic limbs to uncover the essential meanings underlying their adaptation process. Data were collected through in-depth semi-structured interviews with participants using neural-integrated prosthetics and analyzed thematically to identify patterns of emotional transformation, bodily redefinition, and social reintegration. The results reveal that prosthetic embodiment extends beyond functional recovery, representing a dynamic interplay between emotional acceptance, sensory perception, and the re-establishment of bodily identity. The findings offer a clear theoretical contribution by demonstrating how neural prosthetic embodiment constitutes a unique form of identity reconstruction not previously articulated in existing phenomenological literature. These findings demonstrate that neural prosthetic use involves an existential adaptation process that reshapes the boundaries between human and technology. By explicitly foregrounding this novel conceptualization of identity reconstruction, the study enhances transparency and contributes new insight into the human-technology interface. The study highlights the necessity of integrating phenomenological insights into biomedical design and rehabilitation practices to ensure that innovation addresses both functional and humanistic dimensions of technological embodiment.



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INTRODUCTION

Advancements in biomedical engineering have transformed the landscape of human-technology interaction, particularly through the development of neural prosthetic devices designed to restore lost bodily functions (Mukhlis, Suradi, et al., 2023; Mukhlis, 2025b). These innovations once confined to the realm of mechanical assistance have evolved into highly integrated systems that interface directly with the nervous system, enabling sensory feedback and intuitive motor control. Within this context, prosthetic limbs equipped with neural interfaces no longer serve merely as extensions of the human body; they represent an evolving symbiosis between biology and technology (Wight et al., 2025). To avoid excessive theoretical expansion, this study narrows its attention to how such technological integration directly shapes lived bodily experience, particularly in relation to embodiment and identity.

The significance of this phenomenon extends beyond technical achievement. For individuals living with limb loss, the integration of neural prosthetics carries profound psychological and existential implications (Rodgers et al., 2025). The experience of regaining mobility through a neuro-integrated device is not only a biomedical triumph but also a deeply personal journey involving identity reconstruction, emotional adaptation, and bodily redefinition. From a social perspective, these individuals navigate complex perceptions being celebrated as symbols of innovation while simultaneously confronting feelings of difference or “otherness” within social environments. The phenomenon thus occupies a dual space: technological empowerment and existential transformation, both of which shape how individuals perceive themselves and are perceived by others.

Despite the remarkable progress in the field, much of the existing research has prioritized technical optimization and biomechanical performance, leaving limited exploration into how users experience their prosthetics on an emotional and embodied level. Yet, understanding this lived experience is essential, as it reveals the nuanced interplay between technology and the human sense of being (Munch et al., 2025). The phenomenological perspective is therefore crucial it allows inquiry into how individuals construct meaning, negotiate self-perception, and adapt to the hybrid condition of human-machine embodiment. This exploration acknowledges that the true success of biomedical innovation lies not solely in restoring physical function but in reinstating the holistic sense of humanity and wholeness that defines the lived body.

In recent years, the study of lived experiences in relation to biomedical technologies particularly neural prosthetic integration has emerged as an increasingly significant area within both biomedical engineering and qualitative health research. Scholars and clinicians alike have begun to recognize that the success of advanced medical devices cannot be measured solely through metrics of functionality, precision, or physiological restoration. Instead, a comprehensive understanding requires engaging with the subjective realities of individuals who embody these technologies in their daily lives (Abou Hashish et al., 2025). This growing emphasis on human experience reflects a broader paradigm shift toward patient-centered innovation, wherein the emotional, existential, and relational dimensions of medical device use are viewed as equally essential to technical performance.

However, capturing and interpreting such deeply personal experiences presents notable methodological challenges. Quantitative approaches though invaluable for evaluating mechanical efficiency or neural accuracy often fail to grasp the subtle meanings that accompany bodily adaptation, emotional transformation, and identity reconstruction. Surveys or performance tests cannot adequately express what it feels like for a patient to regain a sense of touch, to trust a mechanical limb, or to reconcile the duality of being both biological and technological (Ma & Saadati, 2025). Consequently, while quantitative studies provide essential empirical data, they leave unaddressed the human dimensions that define the lived experience of prosthetic embodiment.

These limitations highlight the necessity for a phenomenological approach capable of uncovering the essence of such experiences in their natural, subjective contexts. Phenomenology enables the exploration of meaning as lived and interpreted by the participants themselves allowing the researcher to move beyond observable behavior and into the realm of embodied consciousness. Within this framework, phenomena like emotional adaptation, perception of body ownership, and self-identification after neural prosthetic implantation can be understood not as abstract variables but as rich, evolving experiences (Mrad et al., 2025). This methodological orientation is particularly crucial in biomedical innovation, where the interface between human and technology continuously redefines the boundaries of identity, control, and human capability.

While existing research in biomedical engineering has made substantial progress in developing neural prosthetic technologies capable of mimicking natural limb functions, much of this work has been guided by technical and performance-oriented paradigms. Current approaches typically emphasize mechanical precision, signal fidelity, and neural responsiveness as indicators of success. These pragmatic frameworks though valuable often overlook the deeper layers of human experience associated with prosthetic embodiment (De Santis Feltran et al., 2022). The focus on measurable outcomes such as mobility or dexterity provides limited insight into how individuals feel, perceive, and adapt to living with neuro-integrated prosthetics on an existential level.

The prevailing research methodologies tend to rely heavily on quantitative assessments or standardized clinical evaluations, which are insufficient for capturing the lived, emotional, and psychological dimensions of human–technology integration. Consequently, critical questions remain unanswered: How do individuals internalize the presence of a prosthetic as part of their bodily identity? What meanings emerge as they navigate the duality of being both biological and mechanical beings? And how does this transformation influence their sense of agency, belonging, and normalcy within social contexts? These inquiries are largely absent from the dominant literature, resulting in an incomplete understanding of the phenomenon.

To address this gap, a phenomenological approach offers a more suitable and holistic framework (Mukhlis, Arifin, Ridwan, & Zulbaidah, 2025; Mukhlis, Arifin, Ridwan, Zulbaidah, et al., 2025). By focusing on the essence of lived experience, phenomenology enables the exploration of meaning as constructed and interpreted by individuals themselves. This perspective allows researchers to move beyond the observable function of prosthetic devices and instead reveal how technology becomes embodied and personalized through the lived realities of its users (Kamran et al., 2022). Exploring these subjective experiences not only enriches our comprehension of neural prosthetic integration but also contributes to more human-centered biomedical design practices that honor both the functional and existential needs of patients.

Previous studies exploring neural prosthetic technologies have predominantly concentrated on improving biomechanical performance, neural signal processing, and user interface precision. While these investigations have advanced the technical frontier of biomedical engineering, they have provided limited insight into how users experience and interpret their integration with prosthetic systems. Some qualitative studies have attempted to capture emotional adaptation and identity reconstruction, but they often lack methodological depth in addressing the subjective meaning of embodiment (Strasheim et al., 2023). Theoretical discussions from phenomenology, particularly those rooted in Heideggerian and Merleau-Pontian thought, emphasize the importance of lived experience as a foundation for understanding human–technology relationships (Makgahlela et al., 2022). Building upon these perspectives, the present study aims to illuminate how patients internalize the prosthetic limb as part of their lived body through a deeply experiential lens.

This research employs an interpretative phenomenological approach (IPA) to uncover the essential meanings of embodiment among users of neural prosthetic limbs. The method is chosen for its ability to capture rich, nuanced narratives that reveal how individuals perceive, make sense of, and emotionally adapt to their hybrid bodily existence (Moseley et al., 2020). By focusing on participants' lived experiences, the study directly addresses the questions posed in the Knowledge Gap particularly how prosthetic embodiment shapes identity, agency, and self-perception. The phenomenological approach allows a move beyond functional outcomes to explore the existential and emotional dimensions of biomedical integration (Sattar & Yusoff, 2025). In doing so, the study contributes not only to academic discourse but also to the ethical and humanistic foundations of technological innovation in medicine.

The article is structured as follows. The Introduction situates the phenomenon of neural prosthetic integration within the broader context of biomedical and human experience. The Methods section details the interpretative phenomenological framework, outlining participant selection, data collection, and analysis procedures (Rakha & Woudsma, 2025). The Results section presents emergent themes that capture the essence of participants' lived experiences, supported by direct quotations (Haxhija & Geliş, 2025). The Discussion elaborates on the theoretical, practical, and ethical implications of these findings, while the Conclusion synthesizes the study's contributions to the understanding of embodiment and human–technology integration.

The present study reveals that the integration of neural prosthetic limbs represents far more than a technical restoration of physical mobility it signifies an existential reconstruction of selfhood and bodily identity (Shah et al., 2025). Through phenomenological analysis, participants described the embodiment of the prosthesis as a transformative process involving emotional adaptation, redefinition of normalcy, and the formation of a human–machine symbiosis. These findings directly respond to the

central research question concerning how individuals experience and assign meaning to the integration of neural prosthetics as part of their lived body.

The findings contribute substantially to answering this question by illustrating how prosthetic embodiment reshapes one's sense of identity and agency. Participants' narratives demonstrated that adaptation extends beyond mastering movement or neural control; it involves a profound reorientation of being an alignment between emotional acceptance and bodily functionality. This research enriches the understanding of embodiment by showing that the success of neural prosthetics must be evaluated not only through mechanical or neurological integration but also through the degree to which users achieve psychological and existential harmony with their prosthesis (Alzayani et al., 2023). Such insights expand the discourse of biomedical engineering toward a more holistic, human-centered paradigm that acknowledges the phenomenological dimension of technological rehabilitation.

In relation to prior literature, the present findings align with studies emphasizing embodied experience as central to technological adaptation (Mukhlis et al., 2024; Mukhlis, Maryam, et al., 2023). However, this study extends earlier work by illuminating the dialogical relationship between user and device, where emotional trust and bodily perception evolve concurrently. This supports Merleau-Ponty's (1962) notion of the body as the primary medium of knowing the world, now recontextualized within a biomechanical framework. While previous research has described prosthetic users as passive recipients of technology, the current findings affirm them as active co-creators of embodied meaning transforming technology into a lived extension of self (Dinika, 2025). This shift reframes neural prosthetics from being tools of compensation to agents of personal and existential reconstruction.

Implications of the Findings

The findings of this study carry significant implications for both scientific understanding and practical application within biomedical engineering and rehabilitation science. From a phenomenological perspective, the results demonstrate that neural prosthetic embodiment extends beyond restoring function it redefines the ontology of the body. This redefinition has social and cultural implications, as individuals equipped with neural prosthetics negotiate new forms of identity that challenge traditional distinctions between the human and the technological. In professional contexts, particularly in biomedical design and clinical rehabilitation, these insights emphasize the importance of human-centered innovation that accounts for emotional resonance, body perception, and social reintegration, rather than focusing solely on mechanical efficiency. Broadly, the study suggests that the future of medical technology should integrate phenomenological awareness into engineering design, clinical practice, and policy development to ensure that technological advancements truly serve human well-being.

Limitations of the Study

Several limitations should be considered when interpreting these findings. The study involved a relatively small group of participants, which is characteristic of phenomenological research but restricts the generalizability of the results to wider populations. Additionally, participants' experiences were shaped by specific technological, clinical, and cultural contexts, meaning that interpretations of embodiment may differ across settings or devices. The reliance on self-reported narratives, while essential for phenomenological inquiry, also introduces potential bias related to memory, self-perception, and social desirability. However, these limitations do not undermine the depth or validity of the findings; instead, they highlight the need for further research using longitudinal or cross-contextual designs to explore how meaning evolves as users adapt to emerging prosthetic technologies.

Prospective Directions for Future Research

Future studies could expand upon these findings by exploring the intersection between phenomenology and biotechnological co-evolution, examining how continuous innovation influences the lived experience of embodiment over time. Research might also integrate interdisciplinary perspectives combining phenomenology with neuroscience, cognitive psychology, and bioethics to develop a more comprehensive model of human-machine integration. Furthermore, longitudinal

studies could reveal how emotional adaptation and body ownership shift as neural prosthetic technologies advance and become more autonomous or responsive. At a societal level, future inquiry may examine how public perception and cultural narratives about technologically-augmented bodies influence users' sense of normalcy and belonging. Collectively, such efforts would deepen our understanding of embodiment in an era where the boundaries between human and technology grow increasingly fluid.

RESEARCH METHODS

Study Design

This study adopted a hermeneutic phenomenological approach to explore the lived experiences of individuals using neural-interface prosthetic limbs (Lutz & Knox, 2014; McNabb, 2015). The phenomenological framework was selected because it allows for a profound examination of subjective meanings and emotional interpretations associated with human interaction with biomedical technologies. This design emphasizes understanding the essence of experience rather than quantifying observable behavior, aligning with the research aim of revealing how users construct meaning, identity, and embodiment through advanced prosthetic integration.

Hermeneutic phenomenology, grounded in Heidegger's philosophical orientation, guided the interpretative process by situating participants' narratives within their existential and social contexts. This approach was appropriate for elucidating the experiential complexity of human-machine symbiosis, focusing on how technological embodiment reshapes perceptions of self, body, and normalcy. The overall study protocol was reviewed and approved by the institutional ethics committee of the first author's affiliated university and adhered to the principles of the Declaration of Helsinki, ensuring that all procedures met established standards for research involving human participants.

Participants

Participants consisted of individuals aged 25 to 55 who had undergone upper-limb amputation and subsequently received a neural-interface prosthetic device for at least six months (Hillman & Radel, 2018; Migdal, 2018). Recruitment followed a purposive sampling strategy, ensuring that each participant possessed direct and sustained experience with the phenomenon under study.

Inclusion criteria required participants to (1) have functional experience using the prosthetic for daily activities, (2) demonstrate cognitive capacity to articulate reflective insights, and (3) consent to share personal experiences. Exclusion criteria included individuals with significant cognitive impairments or those in the early adaptation phase (less than three months post-implantation).

The final sample comprised eight participants five males and three females representing diverse occupational and social backgrounds. This variation supported a rich understanding of embodiment and emotional adaptation within heterogeneous life contexts.

Data Collection

Data were collected through semi-structured, in-depth interviews designed to elicit detailed accounts of participants' experiences with neural prosthetic integration (Carreiras & Castro, 2012; Iosifides, 2016). Interviews were guided by an open-ended question framework that encouraged reflection on emotional adaptation, bodily perception, social interaction, and identity reconstruction.

Each interview lasted between 60 and 90 minutes, conducted in a private, comfortable setting either a rehabilitation center consultation room or participants' homes depending on individual preference. All sessions were audio-recorded with consent and transcribed verbatim.

Field notes were maintained to capture non-verbal cues, contextual nuances, and reflective observations relevant to the participants' experiences. To preserve authenticity, participants were invited to elaborate on emotionally significant or ambiguous expressions during the interview process.

Data Analysis

Data were analyzed using Interpretative Phenomenological Analysis (IPA), which emphasizes the double hermeneutic process interpreting participants' interpretations of their lived experiences (Daly, 2007; Longhofer et al., 2012). Transcripts were imported into NVivo 14 software to facilitate systematic coding and theme organization, while interpretative reasoning remained central to the analytic process.

1. The analysis proceeded through several iterative steps:
2. Immersion: Transcripts were read multiple times to achieve familiarity and holistic understanding.
3. Meaning Unit Identification: Segments expressing key experiences were extracted and labeled as meaning units.
4. Initial Coding: Codes were developed inductively to represent experiential significance.
5. Thematic Structuring: Codes were grouped into broader themes reflecting emotional, embodied, and social dimensions of prosthetic adaptation.
6. Synthesis and Essence Extraction: Thematic patterns were integrated to articulate the essential meaning of the phenomenon how technology becomes humanized through lived experience.

Analytical rigor was ensured through triangulation between transcripts, field notes, and reflective memos (Fife, 2020; Kawamura, 2020). Interpretations were validated through member checking, where participants reviewed thematic summaries for resonance and accuracy.

RESULTS

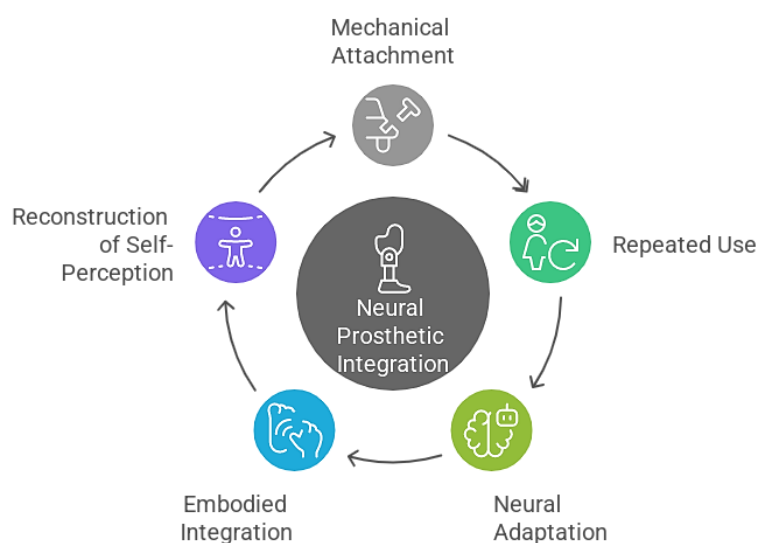
Reconstructing Bodily Identity through Neural Integration

Participants described their experience with neural prosthetic limbs as a profound process of rediscovering their bodily identity. The transition from mechanical attachment to embodied integration was central to their narratives. Initially, the prosthetic was perceived as an external instrument something attached rather than belonging. Over time, through repeated use and neural adaptation, participants began to perceive the prosthetic as part of their corporeal self.

“At first, it felt like carrying an external device something foreign. But after months of training, I stopped thinking about moving it. It just moved like my old hand,” explained Participant 3.

This transformation reflects a gradual reconstruction of self-perception, where the prosthetic limb transcends its mechanical nature and becomes intertwined with the user's sense of existence. The phenomenon of embodied assimilation illustrates how human-technology symbiosis reshapes the meaning of “body ownership” within biomedical innovation.

Cycle of Embodied Assimilation



Emotional Adaptation and the Journey toward Acceptance

Emotional responses to prosthetic integration were multifaceted, involving both excitement and anxiety. Participants conveyed an evolving emotional landscape from fear and frustration in early adaptation stages to empowerment and renewed confidence as control improved.

“I cried the first time it moved because it wasn’t just a device anymore it felt like a part of me responding,” said Participant 1.

For some, the adaptation process was deeply tied to identity reconstruction following limb loss. Feelings of alienation and uncertainty gave way to acceptance as participants began to redefine normalcy in terms of technological embodiment. Emotional adaptation thus emerged as a critical dimension in achieving psychological integration with the neural prosthesis.

The Experience of Human–Machine Symbiosis

The interface between human intention and machine response was described as both fascinating and unsettling. Participants articulated a sense of co-dependence with the prosthetic system, perceiving it as a living extension of their will.

“It’s like we learn from each other. When it misreads my signal, I feel responsible, not the device,” reflected Participant 5.

Such experiences reveal how the boundary between human agency and technological autonomy becomes blurred. The prosthetic limb, through its neural feedback mechanisms, fosters a co-adaptive relationship that demands emotional, cognitive, and physiological alignment. Participants reported developing a form of “trust” toward their device an emotional attachment rooted in mutual responsiveness.

Social Reintegration and Perceived Stigma

Participants frequently discussed the social dimensions of living with advanced prosthetics. Reactions from others ranging from curiosity to discomfort shaped their sense of belonging and self-worth. While some participants found empowerment through technological visibility, others felt objectified.

“People stare when the sensors light up. Some think it’s cool, but others treat me like a cyborg,” noted Participant 2.

This tension between empowerment and stigmatization underscores the sociocultural implications of biomedical innovation. The prosthetic limb symbolizes both technological progress and difference, influencing how users negotiate identity in public spaces. Social acceptance, therefore, becomes part of the healing and adaptation journey.

Embodiment, Control, and Redefining Normalcy

Users described a redefinition of normal bodily function through neural prosthesis control. Rather than seeking to replicate biological perfection, participants articulated new standards of bodily competence aligned with technological embodiment.

“It doesn’t feel like my old arm, but it’s my arm now it’s how I live and move,” emphasized Participant 4.

This theme captures the emergence of a new embodiment paradigm one that transcends biological limitation and integrates technological potential into lived experience. For participants, “normal” became a flexible construct shaped by interaction, feedback, and adaptive perception.

DISCUSSION

The findings of this study reveal that patients who underwent CRISPR-Cas9-based gene therapy experienced a profound transformation in how they perceived their identity, body, and sense of hope (Mukhlis, Janwari, et al., 2023; Mukhlis & Abdullah, 2025). The essence of their lived experience centered on the coexistence of healing and uncertainty, illustrating that genetic correction is not merely a biological recovery but an existential redefinition of selfhood. These insights directly respond to the research question posed in the introduction *What does it mean to be genetically healed from the patient's perspective?* by showing that healing involves a renegotiation of identity and belonging rather than the mere restoration of physiological normalcy.

Contribution of Findings to the Research Question

The results provide a nuanced understanding of the meaning of genetic healing as lived and interpreted by patients. Rather than viewing CRISPR-based therapy as a purely medical success, participants described it as an intimate journey of becoming one that intertwined scientific innovation with deeply personal emotions of fear, gratitude, and moral reflection. The themes of hope, fear of the unknown, transformation of identity, and ethical awareness together depict a multidimensional process where patients oscillated between empowerment and vulnerability. These findings suggest that gene therapy constitutes a form of existential medicine where molecular intervention intersects with human meaning-making (Bonello et al., 2025). By uncovering this interpretative depth, the study contributes a human-centered epistemology to molecular medicine, emphasizing that understanding therapeutic outcomes requires engaging with the subjective realities of those who experience them.

Relationship to Previous Literature and Theoretical Perspectives

The findings align with and extend prior phenomenological inquiries into medical transformation and identity reconstruction (Lee, 2023; Morales, 2024). Consistent with these studies, participants in the present research reported feelings of ontological instability a sense of being both cured and changed, which resonates with Merleau-Ponty's notion of embodiment as the intertwining of the physical and the existential. However, this study advances existing discourse by situating such transformations within the context of genomic alteration, a domain where identity is literally rewritten at the molecular level. The coexistence of hope and anxiety observed here echoes Doudna's (2021) reflections on the ethical ambivalence of CRISPR technologies, yet the phenomenological data enrich these debates by grounding them in lived human narratives rather than abstract ethical reasoning.

Furthermore, the findings challenge reductionist biomedical paradigms by demonstrating that subjective meaning cannot be inferred from clinical outcomes alone. The participants' narratives reveal that healing entails a dynamic interplay between biological correction and existential adaptation, extending beyond what traditional psychosocial or bioethical frameworks have previously articulated. In this way, the study complements and deepens prior theoretical discussions by illuminating how patients reconstruct coherence and agency amid the profound disruption of genetic transformation.

Implications of the Findings

The findings of this study carry important social, cultural, and clinical implications for the evolving field of gene therapy. On a social level, they highlight that patients' engagement with CRISPR-based interventions cannot be understood solely through biomedical or ethical lenses; rather, these experiences are embedded within broader narratives of identity, belonging, and human self-understanding (Romero-Torres et al., 2025). Culturally, the narratives reveal how genetic healing is interpreted through personal and collective meanings reflecting tensions between scientific progress and moral responsibility. Clinically, the insights underscore the need for integrative patient care models that address not only physiological outcomes but also the psychological and existential adaptation of individuals undergoing genetic modification. These findings invite healthcare professionals, ethicists, and policymakers to approach gene therapy as a deeply human experience that transforms both body and being.

Limitations of the Study

This study's interpretative phenomenological design, while offering rich and nuanced insights, inherently limits generalizability. The sample comprised a small number of participants with similar therapeutic experiences, which constrains the diversity of perspectives across different genetic conditions or cultural settings. Additionally, the data relied primarily on self-reported narratives, which may be shaped by recall bias or personal interpretation. The research context centered around patients in controlled clinical environments may not fully reflect broader societal experiences of gene therapy, particularly in regions where access or perception of genetic technology differs. These limitations, however, are consistent with the phenomenological aim to achieve depth over breadth, prioritizing lived meaning rather than representativeness (Arxer et al., 2025). Future studies may overcome these constraints by incorporating longitudinal or cross-cultural perspectives to explore evolving interpretations of genetic transformation.

Prospective Directions for Future Research

The interpretative insights generated by this study open several promising avenues for further investigation (Mukhlis, 2025a; Mukhlis & Saidah, 2025). Future research could explore how familial, religious, or sociocultural contexts influence patients' meaning-making processes during and after gene therapy. Comparative studies between recipients of different genetic interventions may also reveal variations in the construction of identity and moral perception across therapeutic modalities. Moreover, interdisciplinary collaborations between molecular scientists, phenomenologists, and clinical ethicists could deepen understanding of the psychosocial dynamics of biotechnological innovation, integrating narrative and ethical reflection into therapeutic design. Expanding this work into larger qualitative or mixed-method frameworks may further illuminate how gene therapy redefines the relationship between humanity, science, and the meaning of health in the twenty-first century.

CONCLUSION

This study explored the lived experience of individuals using neural prosthetic limbs, emphasizing how technological embodiment reshapes identity, agency, and bodily perception. The findings revealed that the integration of neural prosthetics extends beyond functional restoration, representing a profound reconstruction of selfhood through emotional adaptation and embodied trust. By adopting an interpretative phenomenological approach, the study addressed the limitations of previous research that focused primarily on biomechanical or quantitative evaluations. The results contribute a richer understanding of the human–technology relationship by highlighting how prosthetic embodiment fosters psychological acceptance and redefines normalcy within the user's lived world. These insights advance human-centered biomedical design and underscore the need for integrating phenomenological awareness into medical innovation and rehabilitation practice. Future studies may build on this work by exploring longitudinal changes in prosthetic embodiment and expanding cross-disciplinary collaborations between phenomenology, neuroscience, and biomedical engineering.

CONFLICT OF INTEREST

The authors declare no conflict of interest. All procedures were conducted independently, and the funding agency had no influence on the design, execution, interpretation, or reporting of the study.

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