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EMERGING TRENDS IN DESIGN FOR MUSCULOSKELETAL MEDICINE (S GOLDCHMIT AND M QUEIROZ, SECTION EDITORS)

Innovation in Orthopedics: Part 1—Design Thinking

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Abstract

Purpose of Review This narrative will focus on the adoption of design thinking to improve patient-centered care innovation in Orthopedics.

Recent Findings The literature reveals a complete set of applications of the design thinking approach in the different stages of the patient experience throughout the health context; however, the papers identified focus on specific parts of the process, and there is no systemic analysis about the different aspects involved in each stage of the complete experience. This review presents a holistic analysis concerning the application of design thinking to the distinct phases of innovation development in orthopedics, from the identification of the specific initial challenges up to the introduction of technology-based artifacts, such as innovations in the musculoskeletal health market.

Summary Systematic description of design thinking application to orthopedics, including concepts, methods, tools, and implementation examples in the most relevant phases of the patient experience—clinical treatment, perioperative care, and rehabilitation.

Keywords Design thinking · Immersion · Patient experience · Prototyping · Innovation

Introduction

Design thinking is being successfully applied to tackle the challenge of developing new models of patient-centered care [1•]. Design thinking is a human-centered design approach, focusing on the development of innovative and creative solutions to solve wicked problems [2], including those related to uncertainty, ambiguity, and volatility, resulting in an effective approach for dealing with complex and persistent patient-centered healthcare problems [3]. Design thinking applies human-centered methods, combining complementary research initiatives, creative teamwork, and fast prototyping [4]. In summary, design thinking is "a discipline that applies designer's sensibility and methods to match people's needs with what is technologically feasible and what a viable business strategy can convert into customer value and market" [5].

In the in musculoskeletal (MSK) health context, the most important objective of design thinking is to improve the overall patient satisfaction, as a result of all the experiences lived in the multiple contact points during the journey [6]. The improvement of patient experience demands a holistic approach, and design thinking provides the tools to create innovative solutions that improve musculoskeletal conditions [3], considering risk factors that are common to other chronic health conditions, such as diabetes, obesity, poor nutrition, and a sedentary lifestyle [4, 7]. Orthopedics is challenging both at

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the diagnostic and therapeutic levels, and successful treatment of patients requires teamwork with different stakeholders [8]. Initial challenges are based on the consequences of musculoskeletal disorders, including long-term pain, physical disability, loss of independence, reduced social interaction, and a decline in quality of life [9]. In this context, design thinking prioritizes the needs of the end users to guide researchers in designing initiatives based on the interaction with patients to solve musculoskeletal disorders [10].

However, despite its growing relevance, very few studies have been published concerning the adoption of design thinking as an approach for innovation in orthopedics considering a systemic analysis of the patient experience. Aiming to fill this gap of knowledge, this narrative review will focus on design thinking applied to orthopedics: concepts, methods, tools, and implementation examples in the most relevant phases of the patient experience—clinical treatment, perioperative care, and rehabilitation.

A narrative review was done to map theoretical approaches and themes, as well as to identify knowledge gaps within the literature [11, 12•]. Data collection was done on Web of Science, Scopus, and Pubmed databases, and the initial search considered the specific keywords (“design thinking”) AND (orthopedics).

What Is Design Thinking and Why Is it Relevant for Orthopedics?

Design is a strategic problem-solving process to develop innovative products, systems, services, and experiences [13]. Design thinking thus applies designers’ abductive reasoning to tackle complex problems [14] aiming to obtain solutions that are desired by users, technically feasible and economically viable for the different stakeholders [5]. Design thinking is especially well-suited for the health context since all aspects involved with health and wellbeing are determined by the combination of a number of complex and interrelated factors [15]. Two major drivers increase complexity in the health segment: technology and human-centeredness [16]. Considering the patient perspective, complexity is evidenced from a continuous understanding that an illness is not an isolated phenomenon and should be faced from the understanding of all aspects involved in the patient experience [1•]. From a technological perspective, complexity in the healthcare system results from the development and successful adoption of advanced equipment and materials, innovative procedures, and therapeutics [17, 18]. To deal with complexity, designers, physicians, and health professionals apply a systematic innovation process that prioritizes deep empathy for end-users to develop more comprehensive and effective solutions [4, 19••].

Design thinking projects have three main phases [1•]: “inspiration,” for connecting with distinct stakeholders, understanding circumstances, and identifying problems and opportunities; “ideation,” for generating ideas, developing, and validating prototypes that result in the desired solutions; and “implementation,” for mapping paths to effectively enter markets with new value propositions. Design projects do not follow strict patterns of activities and may return systemically to any phase more than once, as ideas are refined and new directions are taken [5]. The most popular representation of the design thinking approach is the double diamond [20, 21], presented in Fig. 1.

Design thinking begins with the identification of the initial challenge, and the discovery phase aims to involve and to empathize with the people most affected by and knowledgeable about the problem that needs to be solved, including specific aspects related to the different experiences of patients, surgeons, nurses, family members, and other participants [15, 22]. To summarize results, the multidisciplinary team synthesizes distinct perceptions about the most relevant and interesting aspects evidenced in the research phase considering the distinct stakeholders involved and their unique journeys throughout the health context [6, 23, 24••]. Reframing the initial problem is usually the final activity in the problem domain [19••, 25]. In the ideation phase, participants apply creative techniques to generate innovative solutions, capable of achieving desired results, improving specific aspects of health treatments, and creating value for the distinct participants of the creative process [26, 27]. Finally, the design process enters the prototyping and validation phases, in which several ideas are tested with potential users to gain knowledge about the potential advantages and disadvantages of the solution. After the iterative improvement of evolutionary prototypes, an optimized solution is obtained for the initial situation, ready for implementation and scaling considering the specificities of the health context [4].

Inspiration: the Deep Dive

One key aspect of design thinking is the immersion into the complex problem domain of musculoskeletal health contexts. Empathizing, observing, and active listening are fundamental to stimulate people’s involvement and to obtain an understanding of current experiences and related needs and desires [6, 15]. Empathy enables observing a phenomenon taking into account multiples points of view [24••, 28] and promotes integrative thinking, i.e., motivated individuals considering distinct points of view more comprehensively [29]. Another contribution of design thinking during inspiration is connecting different publics around the same topics of analysis. Team building is a central aspect to obtain collaboration among distinct participants, with distinct backgrounds and roles, including physicians, nurses, and pharmaceuticals [1•]. Collaboration is related to understanding each other’s needs and motivations, as well as to creating opportunity for support [19••, 24••]. Collaboration enriches the generation,

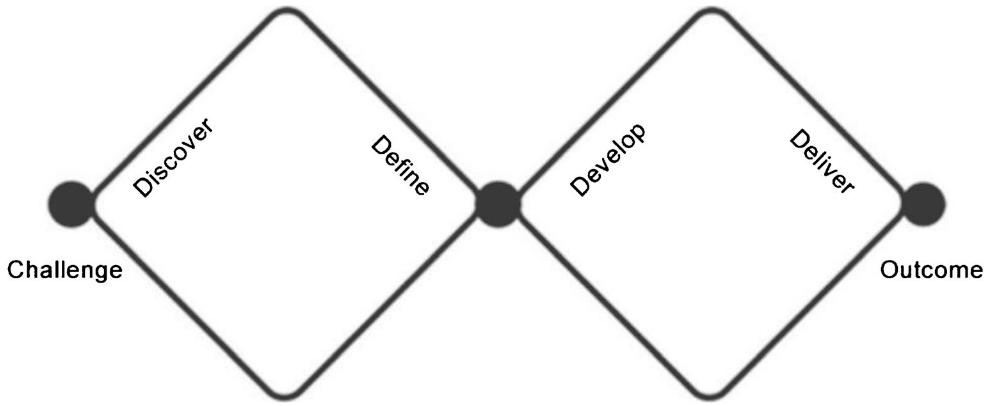

Fig. 1 Design thinking double diamond (adapted from Macduff C et al. Fostering nursing innovation to prevent and control antimicrobial resistance using approaches from the arts and humanities. *Journal of Research in Nursing*. 2020; 25(3):189–207. https://doi.org/10.1177/1744987120914718)

selection, and implementation of ideas, in addition to the dissemination of new practices [12•, 27, 30].

Techniques used in the immersion phase are human-centered and include face-to-face interviews and observation of decision-making behaviors [2, 22, 31], and professionals involved in treatment of orthopedic patients, including surgeons, nurses, physical therapists, occupational therapists, and general practitioners [32]. Ethnography is also a very relevant approach for data collection [33]. It requires the immersion of the researcher within a cultural group, allowing the detailed exploration of the influences of that setting and the examination of the behavior as it is occurring, rather than as reported by the stakeholder in the interview format [31]. Ethnographical techniques include the elaboration of unstructured diaries by patients to capture the hospital-stay experience from their own perspective, shadowing patients during their stay to capture a more complete picture of the phenomenon in the real-time context of an organization [22].

However, the diffusion of wearable technologies enables new methods for quantitative data gathering in the MSK health context, which can be mined with artificial intelligence algorithms in order to complement traditional human-centered qualitative information with advanced knowledge about innovative opportunities [34, 35]. Data sourcing technologies include sensors, smartwatches, and fitness trackers and create paths for orthopedic surgeons to monitor the course of their patients, remotely obtaining data about various parameters related to care [36]. Wearable sensor devices (WSDs) can track vital signs, including temperature and heart rate, movements, position, and acceleration, and may play a significant role in the emerging age of digital orthopedics since they have the potential to promote a healthy lifestyle and to improve patient engagement [37].

Patient Experience: Focusing on What Really Matters

In a patient-centered context, the concept of experience is vital to generate a variety of possible solutions with a potential to benefit the participants involved. Experiences are defined as the sum of all interactions between the participants involved in all the different touchpoints across the continuum of care. Therefore, at each touchpoint, people experience situations, recognize results, and perceive benefits that will be remembered and should be orchestrated considering an organization's culture and its manifestations in processes, policies, communications, actions, and environment [22].

Identifying touchpoints at which distinct stakeholders have their worst experiences narrows the focus towards the most relevant "pain points", i.e., the ones to be considered as starting points and to direct all ideation activities [22]. During the course of health treatment, a patient visits distinct healthcare providers, from different disciplines, creating a journey through the healthcare system, that significantly varies per individual [32]. Poorly managed experiences result in disagreements about roles and responsibilities in the management of patients [30]. For example, in perioperative care, waiting times are key aspects to be observed in the overall experience, including timely access to consultation and eventual surgery [38]. Waiting patients may experience health deterioration, altered capacity to perform usual activities of daily living, and reduced capacity to be productive. There is also evidence that while waiting, patients incur significant costs to handle their condition, including direct costs, such as medication and appointments, and indirect costs, including lost time at work or informal care arrangements [39]. Concerning orthopedic treatments, the literature reveals a complex relationship among the severity of the symptoms and tolerance for waiting time, suggesting healthcare resources focus on alleviating the deleterious effects of waiting for certain patients rather than reducing absolute wait times [40].

Prototyping and Validation: the Path Towards the Market

Transition from ideation to implementation follows with the iterative refinement of evolutionary prototypes, created during ideation activities and improved until obtaining appropriate performance to satisfy distinct needs and regulatory constraints. Prototyping aims to evidence possibilities and limitations of design ideas in the simplest and most efficient way [41]. Prototyping includes the creation of unique representations, using different media to be perceived, experienced, and analyzed by the distinct stakeholders involved in the design process [42], such as patients, surgeons, and physicians, among others [1•, 43].

Prototyping clinical treatments, preoperative care, and rehabilitation in orthopedics is of special importance for improving patient experience, reducing pain, restoring function, and obtaining higher life standards. Prototypes are evolutionary approximations of what future products and services will be and incorporate design hypothesis that will be validated to align the development of new concepts with problem definition and challenge resolution [42]. Prototyping activities combine and manipulate physical and digital artifacts and experiment with new materials [41]. Prototyping aligns usability and user experience throughout software and systems development, iteratively exploring the context of use and the design space, promoting collaboration and validation with users and stakeholders [44].

Experience prototyping aims to provide a sense of a real experience and to promote reflection upon them before products and services exist [41]. Clinical redesign understand, define, and improve clinical processes that underpin the patient journey across the continuum of care, promoting collaborative team-based care models and the adoption of emerging technologies to improve efficiency [45, 46]. In the orthopedic journey, experiences transcend clinical and hospital environments, and patients may be suitable for early discharge to home with appropriate support services, including education for patients and caregivers, or may be discharged to inpatient rehabilitation facilities to allow for more advanced medical care [47]. During rehabilitation, design thinking contributes to improving individual's ability to actively live a healthy lifestyle [48]; for example, to transform physical therapy into game play and art creation, gesture-based interactive platforms have been developed [49]. In extreme cases, amputation may be required, limiting the amputee's participation in distinct aspects of life, including sports, hobbies, and housework, a limitation that can be mitigated by the creation of accessible devices to help to hold using materials, such as three-dimensional (3D) printed plastic [50].

Human-centeredness is also essential for designing prototypes that embody emerging digital technologies, including 3D computer-aided design and digital manufacturing that results in rapid prototyping for individually customized devices [51]. Virtual reality (VR) and augmented reality (AR) are also rapidly growing digital technologies thanks to their wide application potential to computing environments with the use of electronic devices. They complement human functions, providing sophisticated simulations in immersive environments for training and performing remote surgery procedures, which can be used for different orthopedic subspecialties [52]. The application of design thinking contributes to prioritizing efforts to promote technological advances, including the search for better materials that can be used for enhanced surgery success, such as cell seeding scaffolds, cell-laden hydrogels, electrical cell guiding biomimetic tissue materials, nano-composites, and cellular therapy injections [18, 52]. Telemedicine platforms are the backbone of virtual care and quickly became an invaluable resource for healthcare systems, including orthopedics [37, 53]. Patient engagement encourages patients to become educated participants in their own care [54]; in this context, patient engagement platforms (PEPs) provide both patients and physicians with an interface to interact and to facilitate longitudinal care. Surgical scheduling platforms simplify the complexity of canceling and rebooking procedures [37]. COVID-19 pandemic led to the nearly overnight end of clinic visits and a rapid rise in virtual care, with many practices going to nearly completely online; in this digital context, chatbots can triage calls freeing staff to focus on more complex tasks [54]. Moreover, the COVID-19 pandemic has also elevated the importance of data, data science, and data-driven decision-making to the forefront of medicine and national policy, since leaders have struggled to make important life and death decisions because of the lack of high-quality data to guide them [37].

How to Innovate with Design Thinking?

There are some relevant challenges that emerge from the specificities of the health contexts that must be overcome to successfully translate the resolution of complex problems into innovations for the market.

I. *Promoting and supporting a cultural transformation*: design fosters innovation development from the resolution of complex problems with the application of an abductive reasoning [13, 14], resulting in an experimental trial and error approach that has inherent uncertainties and risks [55]. However, many of the initiatives towards quality improvement in the health context aim to minimize risks and handle uncertainties [56], resulting in conflicting perspectives that have to be harmonized. Therefore, in a design context, cultural inclusiveness must be supported to successfully include conflicting cultural viewpoints [8]. Moreover, immersion activities should prioritize the researchers' concrete experiences within the health context of interest to allow the thorough exploration of distinct influences of that setting and the examination of the patient's behavior [31]. During ideation, multidisciplinary teams should consider cultural values embedded in economic, regulatory, technological, and legal systems that may be influencing attitudes and beliefs [57]. Finally, a cultural shift regarding an inclusive and holistic patient perception in hospitals and in other contexts should be stimulated [6].

II. *Understanding the nature of problems*: design, as the science of the artificial [58], is well-suited for approaching complex problems, yet it is of little use when solving well-defined problems. Design thinking initiatives are human-centered, such as designing for an aging population, that will be more functionally dependent [59], demanding initiatives to maintain the physical capacity [60], with greater probability of accessing healthcare services [47], considering the need for "social distancing" caused by the COVID-19 pandemic that complicates traditional care model for recovery after medical procedures that demand intensive physical therapies [37]. Moreover, to align current and future services, new models of care need to be developed, to ensure that the right care is delivered at the right time by the most appropriately trained health professional and at a reasonable cost [4, 17].

III. *Working with multidisciplinary teams*: the creative processes, working with multidisciplinary teams including orthopedists, rheumatologists, traumatologists, physical therapists, and other health professionals who deliver care to those with musculoskeletal conditions, enable analyzing and creating considering distinct and complementary perspectives and results in improved value [17, 24••].

IV. *Applying the design process*: empathize, i.e., experience and understand the different moments experienced by the patient throughout his/her journey, from the discovery of the first symptoms to the full recovery, considering surgical interventions, rehabilitation and eventual drug treatments [6, 47]; define, based on the information gathered, to classify needs and insights, identify personas and their journeys, and evidence opportunities for improvements that will guide the subsequent creative processes [22]; ideate, to identify a large number of potential solutions to solve the previously identified needs considering the proposed personas and their journeys through the healthcare system [5]; prototyping, with the creation of evolutionary artifacts to be tested with the potential user [61]; and validating, to get feedback concerning usability and experiences to make adjustments and refinements to improve prototypes towards the final solution.

V. *Promoting the evolution of promising ideas*: Design thinking most valuable contribution is the identification of innovative solutions for complex problems. However, the process usually ends with the initial validation of low-fidelity prototypes that require significant efforts to become a profitable reality in the market. Recently, the diffusion of the Sprint approach [62, 63], based on refining the initial prototype to elicit requirements that guide system development at innovation labs, contributes to bridging the gap between research and development in the orthopedics context and to promoting the adoption and integration of digital health tools into the healthcare delivery model for musculoskeletal patients [37].

Conclusions

Design thinking is an effective approach for creating human-centered innovations in the health context. In orthopedics, this approach enables an empathetic understanding of multiple stakeholders' journeys. Immersion, creation, and implementation are design thinking main phases, and each phase evidences potential challenges and opportunities. Design thinking facilitates the prototyping of new products and services for solving the main demands of orthopedic patients, contributing to the maturation of innovative technologies and their incorporation in different treatments and therapies.

This narrative review focused on the most relevant aspects of design thinking applied to orthopedics: concepts, methods, tools, and implementation examples in the most relevant phases of the patient experience, contributing to filling the gap of knowledge by providing a holistic perspective concerning the application of this approach to the orthopedics context.

Declarations

Conflict of Interest/Competing Interests The authors declare no competing interests.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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