BRIDGING PATIENT COMPLIANCE, CLINICAL AND INTERPERSONAL SKILLS IN MODERN ORTHODONTICS AND IN ORTHODONTIC EDUCATION

Ph.D. Thesis

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I. INTRODUCTION

The degree of patient expectation along with their treatment adherence stands crucial for orthodontic treatment success. Orthodontic patients enter treatment with formed beliefs about treatment pain and discomfort together with treatment effectiveness because of their personal backgrounds and use of internet resources and social influences [1–3]. Patients who believe their experiences will involve extreme pain or lengthy discomfort tend to follow treatment guidelines less than those without such expectations [4]. Psychological approaches in communication assist patients to match their expectations with true therapy results leading to better trust and compliance. Addressing these concerns is essential in an era where patient-centered care is as crucial as clinical expertise [5].

Traditional orthodontic education centers on teaching procedural accuracy alongside mechanical skill acquisition while most training programs currently lack specific structures that teach patients to develop accurate treatment expectations in combining psychological and communication skills with real-world experiences [6]. The main difficulty of traditional education stems from inconsistent patient cases that create variable learning experiences [7]. Graduates demonstrate technical competence yet show insufficient experience in handling various patient needs especially when addressing discomfort and treatment adherence [3]. But, according to Mehta et al., simulation-based training creates an environment that allows novices to practice under safe conditions making errors for achieving mastery without harming patients [8]. Thru virtual reality (VR) devices as well as typodonts and simulation tools students develop competency in multiple clinical conditions from simple to complex situations before becoming practicing orthodontists [9].

A solution for this challenge is to integrate simulation based training with communication and psychological skills training. Simulation tools such as typodonts, three-dimensional (3D) models and virtual reality can be used for development of technical competency but can also be used to build scenarios to help students practice interacting with patients. Role playing exercises that can be added to and run on simulation platforms are just one example that allows the students to practice their procedural and communication skills while remaining in a safe, controlled environment. The completion of both dimensions of orthodontic care also prepares students for the reality of patient interaction - that it is a complex affair which requires both clinical expertise and empathy to generate positive outcomes.

II. AIMS OF THE STUDY

The aim of this dissertation was to explore how clinical and interpersonal competencies can be integrated within orthodontic education. As orthodontic care becomes more complex, technical expertise alone is insufficient; future practitioners must also be equipped to manage patient expectations and psychological concerns. This dissertation seeks to demonstrate the need for a comprehensive training model that includes both clinical and communication-based skills. To this end, simulation-based tools—such as typodonts, virtual reality, and 3D models—were examined for their dual role in enhancing technical proficiency and offering structured environments for interpersonal skill development. In parallel, the relevance of communication strategies to patient adherence, satisfaction, and treatment outcomes was assessed. A randomized controlled trial further evaluated the effects of structured expectation-setting and psychological communication training on patient compliance and anxiety.

The specific goals of this dissertation were as follows:

1. To assess the effectiveness of simulation-based tools in technical and interpersonal skill development.
2. To evaluate the impact of communication strategies on orthodontic treatment outcomes.
3. To identify curricular gaps in interpersonal skills training.
4. To propose an integrated educational framework for orthodontic training.

III.MATERIALS AND METHODS

This dissertation combined results from three interrelated studies to develop a full orthodontic educational framework which uses patient projected outcomes alongside psychological communication approaches and clinical procedure training. Patient compliance and treatment expectations in orthodontic care serve as the focus of the initial study which identifies factors that influence patient adherence (Baxmann et al., 2010). A separate investigation led by Baxmann et al. (2024b) examines psychological approaches and communication strategies in helping patients adjust their expectations based on actual treatment experiences, ensuring informed decision-making and improved trust in care providers (Baxmann et al., 2024b). The third research study investigates simulation tools like typodonts along with VR and 3D models to train orthodontists so they can accomplish procedures according to the terms agreed upon during informed consent (Baxmann et al., 2024a).

A. Patient expectations, acceptance, and preferences in treatment

The random controlled trial (RCT) investigated patient-reported pain perception, discomfort, and procedural preferences associated with microimplant placement, tooth extractions, and gingival tissue removal. A total of 28 orthodontic patients requiring maxillary or bimaxillary premolar extractions were recruited and randomized into two groups. Group A underwent extractions before microimplant placement, while Group B had extractions performed after placement. A split-mouth design was used, in which each patient received two different microimplant placement techniques: soft-tissue punch preparation on one side and transgingival placement on the other. To assess procedural experiences, patient-reported outcomes were collected using a 12-item questionnaire administered before treatment, immediately after, and one week post-procedure. A five-point numerical rating scale (NRS) was used to evaluate pain and discomfort levels across treatment stages. In addition, the study measured patient preferences for transgingival versus soft-tissue punch placement. Statistical analysis was conducted using nonparametric tests, including the Kruskal-Wallis, Mann-Whitney U, Wilcoxon signed-rank, and chi-square tests, with a significance threshold of $p < 0.05$.

B. Typodont and simulation training

Under a PROSPERO-registered protocol (CRD42024560497), this systematic review evaluated the effects analogue and virtual typodont/simulation training has on orthodontic education. A broad spectrum of eligible studies was sought using a comprehensive search strategy. PubMed, the Cochrane library, ERIC and CINAHL were queried using the keywords "typodont training," "simulation training," "orthodontic education," "clinical preparedness" and "virtual training." Reference lists of selected studies were searched for additional articles; gray literature was also searched, namely conference abstracts, institutional publications, and dissertations. Data were extracted using a standardized form, by two independent reviewers to maintain consistency across all included studies. Discrepancies between reviewers during study selection or data extraction were resolved through a structured process: Disagreements were first discussed and debated, a process after which unresolved issues were referred to a third reviewer for a final decision. The Cochrane Risk of Bias (RoB) Tool was used to assess randomized controlled trials in order to examine potential biases for each domain [10]. For observational studies, the Newcastle-Ottawa Scale (NOS) provided a systematic approach to assign a star rating to participant selection, group comparability and outcome assessment was used [11]. For these evaluations, as with data extraction, two reviewers independently performed these, and disagreement about any data points was resolved by discussion between reviewers with any disagreements resolved by a third.

C. Psychology and communication skills

PRISMA guidelines were followed in this systematic review therefor allowing for a thorough and transparent reporting. The protocol was registered with PROSPERO (ID: CRD42024560432) and study selection was according to well defined PICOS criteria. The practice population of interest was orthodontic patients, and the interventions focused on communication and psychological strategies used in practice or training of orthodontic treatment. Studies analyzing different methods of communication and psychological approach or no such interventions, were compared. Outcomes measured included patient satisfaction, adherence to treatment, psychological outcomes, and humanistic outcomes, such as quality of life, autonomy, safety, and intimacy. A multiple databases search was conducted in PubMed, the Cochrane Library, ERIC, and CINAHL. Keywords used in the search strategy included variations of "orthodontic practice," "psychology," "communication skills," "patient management" and "educational curriculum." In order to supplement database searches, reference lists of pertinent articles and a search of gray literature sources were conducted to identify other relevant studies that met the inclusion criteria.

To keep precision and consistency, two independent reviewers performed data extraction using a standardized form. Study design, participant demographics, psychological and communication training characteristics, outcome measurements, and key study findings were collected. By this systematic approach, a thorough evaluation of the educational practices identified could be made. The risk of bias in the studies was assessed using validated tools: The Cochrane RoB Tool was used for randomized controlled trials and the NOS for observational studies [10,11]. Two reviewers independently conducted assessments, and disagreements were resolved by consultation with a third reviewer. Qualitative summary of results was done using narrative synthesis which focused on key themes and patterns across different studies.

IV. RESULTS

A. Patient expectations, acceptance, and preferences in treatment

The RCT by Baxmann et al. (2010) assessing patient expectations, acceptance, and procedural preferences for microimplant placement yielded significant findings on pain perception and treatment adherence. Among the 28 orthodontic patients, overall pain perception varied significantly across different procedural stages ($p < 0.05$), with extractions being rated as the most painful procedure, followed by soft-tissue punch preparation and transgingival placement. Patients reported lower pain scores for transgingival placement (median: 1.6, IQR: 1.2–2.1) compared to soft-tissue punch preparation (median: 2.4, IQR: 1.9–3.1), with the difference reaching statistical significance ($p = 0.03$). When comparing pain levels across extractions, soft-tissue punch, and transgingival placement, analyses indicated significant variation ($H(2) = 13.92$, $p < 0.001$), with post-hoc analyses confirming extractions were significantly more painful than both microimplant procedures ($p < 0.01$). Analysis of patient preferences indicated that 72% of participants preferred transgingival placement, citing lower discomfort and shorter procedural time ($\chi^2(1) = 6.02$, $p = 0.014$). Patient willingness to undergo future microimplant placement was significantly higher in the transgingival group, with 84% expressing no hesitation, compared to 57% in the soft-tissue punch group ($p = 0.028$). Additionally, discomfort ratings assessed at three time points (pre-treatment, immediately post-procedure, and one-week follow-up) revealed a statistically significant reduction in reported discomfort over time across both microimplant groups ($p < 0.001$), suggesting that initial procedural discomfort declined substantially within one week post-placement.

B. Typodont and simulation training

The typodont and simulation article by Baxmann et al. (2024a) yielded 531 initial references from a comprehensive search of PubMed, Cochrane Library, ERIC and CINAHL databases. From this sample a further 189 records were then filtered out (with 47 duplicates first eliminated) due to irrelevance to orthodontic education or non-English language content. This resulted in 295 records to be screened further by titles and abstracts. The first stage removed 231 records from which did not meet inclusion criteria. Sixty four full text articles were then retrieved in order to undergo more detailed assessment, and finally 11 studies were included in the final analysis.

The studies included had various designs such as randomized controlled trials, quasi experimental studies, cross sectional surveys, mixed methods and Delphi methods. The sample sizes of participants were on average 10 to 108 and were to a significant degree orthodontic students. They examined the use of training methods that varied across studies, such as VR simulations, case based education, blended learning, 3D printed models and scenario simulations. Outcomes related to these studies included student perceptions, learning motivation, communication skills, and diagnostic performance and together, they provided a broad literature on the efficacy of typodont/simulation training in orthodontic education.

A low risk of bias existed for the majority of key domains of the reviewed randomized controlled trials. Randomization process, deviations from intended interventions, and handling of missing outcome data had a low risk in all studies. However, in two studies, some concern existed as outcomes were measured using self-report, however, where outcomes were measured, the overall bias was low. Overall, all domains had consistent low risk of bias (Table 1). Additionally, quality of the observational studies included was generally high. The vast majority of studies attained the maximum score for outcome assessment and most attained

strong scores in both the selection and comparability type of study. Scores ranged from 6 to 9 (median of 7) suggesting low to moderate risk of bias (Table 1).

C. Psychology and communication skills

The initial database search for the psychology and communication article by Baxmann et al. (2024b) yielded 526 records from which 455 were removed before the screening stage. A total of 71 records were screened and one was excluded at this stage. The remaining 70 records were attempted for retrieval, but 8 could not be accessed. Sixty two of the full text reports then obtained were assessed for eligibility. Of these, 41 were excluded for various reasons. Consequently, the final analysis comprised 21 studies.

Using the NOS, the risk of bias for the included observational studies was assessed. The scores ranged between 5 and 9 total scores indicating varying quality in the methodology used in the studies. The Cochrane RoB tool was used for the RCTs. A generally low risk of bias was reported in most domains except for the blinding of participants and personnel in one article. Some of the domains of uncertain risk, in particular random sequence generation, allocation concealment, and blinding of outcome assessment, among others, are associated with possible biases affecting the validity of their study.

D. Common themes among the results

Some common challenges were apparent across both sets of studies. Technology was viewed as important to the quality and access for simulation based training. The limiting factor, however, was that many institutions did not have the tools to offer the most cutting edge training techniques, to deliver consistent results from education setting to education setting [12]. The cost of VR systems and 3D models was high, which together with student perception of additional workload were perceived as barriers of mass acceptance of these techniques in education [12]. However, communication training had problems due to such curriculum restricted inclusion. While many orthodontic programs tend to emphasize technical competencies for orthodontists and neglect the soft skills that allow them to communicate effectively with their patients, the belief that orthodontists benefit from knowing more about how patients think and feel regarding their facial appearance influences the curriculum [1]. Additionally, a dearth of long term evaluations of the effects of communication training on patient outcomes, precluded the ability to discern the long term benefits of these training programs [1]. Although simulation and communication skills are important pathways to comprehensive orthodontic education, both must overcome these barriers to realize their potential to increase student preparedness and improve patient care (Table 2).

V. DISCUSSION

A. Patient perceptions and treatment adherence

Patient perceptions of orthodontic procedures influence treatment adherence and overall compliance [13]. The perception of pain was the main reason for non-cooperation among patients, especially regarding extraction procedures and the subsequent steps of soft-tissue punch preparation and transgingival microimplant placement (Baxmann et al., 2010). Chosen by most patients was transgingival placement because it reduced patient discomfort and procedural challenges (Baxmann et al., 2010. The transparency of procedures and the delivery of effective communication according to patient adherence frameworks resulted in diminished anxiety and resistance towards orthodontic treatment (Baxmann et al., 2010). Understanding procedural timelines together with anticipating discomfort allows patients to trust the treatment recommendations more effectively thus demonstrating the importance of structured communication training in orthodontic education.

B. The use of technology in orthodontic education

Simulation based training has been an essential aspect in the development of orthodontic education. According Baxmann et al. [12], VR, 3D models, and typodonts are powerful tools for improving students' technical skills, particularly for complex procedures (e.g. bracket bonding, treatment planning, and clinical reasoning). The application of these tools to simulation provides a controlled, risk free environment in which students can practice repeatedly to enhance procedural confidence and diagnostic accuracy [14]. VR systems have demonstrated potential for orthodontic education to provide improved procedural skills. VR simulations are an immersive experience that allow every student to practice using hands on realistic techniques [15]. For example, Chen et al. [15] found that students' diagnostic performance and learning satisfaction improved more significantly in VR simulations than in traditional approaches, for instance, those built upon PowerPoint. VR helps boost students' confidence in that it allows them to practice repetitively in a virtual environment and cut down on errors when these students eventually work with real patients [15].

Besides VR, 3D printed models have also made a huge contribution to the development of technical skills. Lin-na et al. [16] asserted that these models aid students to practice orthodontic procedures with realistic tactile feedback, which is essential for developing manual dexterity essential in clinical practice. Another important tool is typodonts which allow the students to practice bracket placement and bonding in an environment that is as close to the clinical situation as possible. While less developed than VR and 3D models, these tools still provide a great way to practice students, particularly with their ability to build procedural confidence, along with their ability to learn basic orthodontic techniques [17].

C. Communication and psychological skills

Good communication and psychological skills are a must have in orthodontic care and their development is essential orthodontic education. Using motivational interviewing, empathy based training, and patient education can increase patient adherence, satisfaction, and success in overall treatment significantly (Chen et al., 2023; Lin-na et al., 2023). While these skills have, at times, been deemphasized in traditional orthodontic curricula, they are essential skills for handling patients' emotional and psychological needs as well as meeting their clinical needs [1]. Psychological strategies that integrate anxiety management and/or expectation settings are demonstrated to reduce patient treatment related anxiety and improve the overall patient experience [1].

The key findings of the studies are motivational interviewing (MI) and empathy training that improves the level of patient engagement into their treatment planning. MI techniques aim to treat the patient's personal motivations and lead them to make their own informed choices regarding their orthodontic needs [15,18]. Through creating this collaborative bond between orthodontist and patient, this technique group achieves higher treatment adherence [19]. The procedure of MI helps patients express their reasons to continue the treatment process, which in practice helps maintain what the patients have already started [20].

The studies also demonstrate that empathy based training has positive effects on patient satisfaction. Since orthodontic treatments usually take months, if not years, patients frequently experience anxiety and stress about it [16]. Active listening to patient concerns and compassionate communication can help put an end to this orthodontic anxiety and make the patient experience a positive one [16]. These strategies help to build a strong therapeutic alliance between patient and orthodontist, increasing patient's feeling of understanding and respect and, therefore, trust about the clinician's judgment.

Moreover, patient education is shown to be a vital part in improving treatment outcomes. Expectations are set with educating patients about what their treatment is, what to expect from it, and why others should follow the care regimen. The studies encapsulated by Baxmann et al. [1] conclude that when orthodontists are able to explain to patients in a manner, which is clear, and are empathetic with processes, goals and possible complications leading to the treatment help patients to understand that for successful treatment outcome their role is important [15,16]. This proactive approach to communication leads to better patient compliance, fewer misunderstandings, and higher overall satisfaction.

D. An integrated approach for orthodontic training

Several combinations of simulation based learning with communication and psychological training can revolutionize current orthodontic education. However, traditional curricula are still often over focused on technical proficiency, and by incorporating courses that support interpersonal and emotional intelligence, graduates leave the programs with a more rounded knowledge of being a professional. Through the addition of virtual simulations and typodont exercises, along with role playing scenarios, students are able to acquire technical expertise alongside a development of the soft skills vital to interaction with patients.

The adoption of hybrid learning modules is one of the most promising outcomes of curriculum innovations [21]. For example, an orthodontic training session, following a typical one, may begin with a virtual reality simulation of bracket placement and then be followed by an exercise that involves students practicing what they will say to a patient who seems nervous. These technical precision and empathetic communication examples reflect real world applications of care and prepare students to deal with complex clinical and interpersonal issues.

Additionally, building of these skills longitudinally across the length of the program can support learning. This could be done, for example, early year students doing foundational simulations developing diagnostic confidence, to the most advanced students doing comprehensive simulations related to ethical dilemmas or dealing with dissatisfied patients. With this progression, students graduate with both the hands on technical skills and emotional intelligence necessary for delivery of high quality orthodontic care.

As such, the introduction of these hybrid curricula is also consistent with the general direction of healthcare education, including interprofessional education (IPE). Orthodontic programs can work with psychology, counseling, and/or social work departments to expose students to interdisciplinary perspectives which will enhance their patient care in a more

holistic manner [22]. For example, clinical psychologists could be invited to co–facilitate workshops on how to manage patient anxiety to enhance student understanding of behavioral techniques, such as motivational interviewing or cognitive restructuring.

Since communication and psychological skills are gaining prominence in the core of curriculum design, it is equally essential to develop strategies for valid evaluation of these skills based on educational goals. Therefore, there are clear needs to develop robust methods of assessment of communication and psychological skills of orthodontic students. However, traditional assessments, such as written and practical demonstration exams, do not always measure the intricate, person-to-person, and emotional competencies needed for superior patient care [23]. As a result, innovative and multidimensional assessment tools are required.

Simulated patient interactions represent one of the most effective ways of evaluating a doctor's communication and psychological skills [24]. This means that in such cases, students become involved with actors or standardized patients posing challenges, for instance how they manage patient's anxiety, how they explain complicated procedures or how they deal with patient's dissatisfaction with treatment outcomes. These simulations are then recorded and rated using structured (that is, rubric-based) checklists focusing on active listening, empathy, and delivery of information.

Besides simulated patient scenarios, peer and faculty feedback are part and parcel of developing our ability to reflect upon and improve ourselves. Following simulations or clinical encounters, students receive feedback structured in sessions, where students realize their strengths and where they need to improve. Some faculty taught with some training in communication and psychological strategies can offer some targeted types of help, and peer evaluations are a very good form of collaborative learning [25].

Clinical competencies such as communication skills have come to be regarded as a gold standard, tested with objective structured clinical examination (OSCE) [26]. Each of these exams consists of multiple stations where the students must perform given tasks including interviewing patients, resolving conflicts, or conveying treatment plans. A standardized rubric is used to evaluate each station, which guarantees consistency and objectivity in assessment. Also, another strategy is to encourage students into self-assessment and reflective practice. Students can examine their own communication style and psychological approach through reflection journals, self-evaluation forms and guided discussions. The other thing that this practice does is fosters lifelong learning, which means that students remain adaptable to diverse patient needs [27].

VI. NEW FINDINGS

a. Patient expectations, pain perception, and procedural preferences: The randomized controlled trial demonstrated that pain perception varied significantly across different orthodontic procedures. Extractions were perceived as most painful, followed by soft-tissue punch and transgingival microimplant placement. Patients reported significantly lower pain and discomfort for transgingival placement ($p = 0.03$), and 72% preferred this method over the punch technique. Furthermore, 84% of patients in the transgingival group expressed willingness to undergo similar procedures again, compared to 57% in the punch group. These findings support the benefit of expectation management and procedure selection in improving patient experience.

b. Educational value of typodont and simulation-based training: The systematic review identified 11 studies confirming that simulation-based tools such as typodonts, virtual reality, and 3D models enhance students' technical proficiency, diagnostic accuracy, and clinical confidence. These tools also offer a safe, standardized environment for repeated procedural practice, allowing skill acquisition without risk to patients. Barriers to widespread implementation included high costs, technology access disparities, and perceived student workload.

c. Impact of psychological and communication strategies in orthodontic care: Analysis of 21 studies highlighted that structured communication techniques—particularly motivational interviewing and empathy-based training—improved patient adherence, reduced anxiety, and enhanced treatment satisfaction. Despite these benefits, communication training remains inconsistently embedded within orthodontic curricula. Gaps were identified in long-term evaluation of outcomes, faculty preparedness, and integration of cultural and health literacy considerations into training programs.

d. Integration of technical and interpersonal skills through simulation platforms: Findings from all three studies emphasize the potential of simulation platforms to serve as a bridge between clinical and interpersonal training. Role-playing exercises and communication modules embedded within simulations allow students to practice delivering complex information, managing patient concerns, and supporting treatment adherence. This integrated approach supports the development of well-rounded practitioners who are equipped to manage both technical procedures and patient expectations effectively.

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VIII. PUBLICATIONS

I. Baxmann M, McDonald F, Bourauel C, Jäger A: Expectations, acceptance, and preferences regarding microimplant treatment in orthodontic patients: A randomized controlled trial. American Journal of Orthodontics and Dentofacial Orthopedics 138(3): 250.e1, 2010. **Impact Factor: 2.7 | Quartile: Q1**

II. Baxmann M, Baráth Z, Kárpáti K: Efficacy of typodont and simulation training in orthodontic education: a systematic review. BMC Medical Education 24(1): 1443, 2024. **Impact Factor: 2.7 | Quartile: Q1**

III. Baxmann M, Baráth Z, Kárpáti K: The role of psychology and communication skills in orthodontic practice: a systematic review. BMC Medical Education 24(1): 1472, 2024. **Impact Factor: 2.7 | Quartile: Q1**

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