

IMPLICATION OF PERSONALIZED MEDICINE IN MAXILLOFACIAL SURGERY

Ph.D. Thesis Booklet

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1. Introduction

1.1. What is the topic?

The topic of this PhD research is the clinical implication of personalized medicine in maxillofacial surgery, with a focus on patient-specific implants (PSI). Advances in digital imaging, computer-aided design, and additive manufacturing have enabled the development of implants tailored to individual patient anatomy. These technologies promise improved functional outcomes, reduced complication rates, and enhanced surgical efficiency compared to conventional non-customized implant systems.

1.2. What is the problem to solve?

Despite increasing clinical use, the benefits of PSI remain inconsistently defined. Current evidence is heterogeneous, outcome reporting is variable, and clinical indications for personalized implants are not clearly established. As a result, implant selection is often based

on surgeon preference, availability, or cost rather than robust comparative evidence.

1.3. What is the importance of the topic?

Maxillofacial reconstruction aims to restore function, aesthetics, and quality of life in anatomically complex regions. Procedures such as temporomandibular joint (TMJ) replacement and cranioplasty (CP) are associated with high complication rates and long-term functional consequences. Clarifying the value of personalization in these procedures is therefore of high clinical relevance and directly impacts patient outcomes, healthcare costs, and surgical decision-making.

1.4. What would be the impact of our research results?

By systematically evaluating the safety and efficacy of PSI compared to conventional implant systems, this research provides evidence-based guidance for implant selection. The findings contribute to more rational,

indication-driven use of personalized implants and support the integration of personalized medicine into maxillofacial surgery.

2. Objectives

2.1. Study I. – Comparative efficacy of patient-specific and stock implants in temporomandibular joint replacement

The objective of Study I was to compare patient-specific and stock TMJ implants with regard to functional outcomes, pain, and dietary function. The study aimed to determine whether PSI provide measurable clinical advantages, particularly in long-term functional recovery.

2.2. Study II. – Comparative efficacy of patient-specific versus hand-molded implants in cranioplasty

The objective of Study II was to evaluate the safety and effectiveness of PSI compared with hand-molded (HM) implants in CP. The study focused on implant-related complications, operative time, reoperation rates, and cosmetic outcomes across different materials.

3. Methods

3.1. Study I. – Comparative efficacy of patient-specific and stock implants in temporomandibular joint replacement

A systematic review and meta-analysis were conducted according to PRISMA 2020 guidelines and the Cochrane Handbook. Eligible studies included adult patients undergoing total TMJ replacement with either patient-specific or stock implants. Primary outcomes were maximum mouth opening (MMO), pain, and dietary function. Data synthesis was performed using random-effects meta-analytic models.

3.2. Study II. – Comparative efficacy of patient-specific versus hand-molded implants in cranioplasty

A systematic review and meta-analysis were performed following PRISMA 2020 guidelines. Studies comparing patient-specific and HM CP implants were included. Outcomes of interest were implant removal, surgical site infection (SSI), total reoperation, operative time, cosmetic results, and implant costs. Random-effects models and material-specific subgroup analyses were applied.

4. Results

4.1. Study I. – Comparative efficacy of patient-specific and stock implants in temporomandibular joint replacement

A total of 42 studies involving over 2,200 patients were included. Patient-specific TMJ implants demonstrated a significant improvement in MMO beyond 12 months

postoperatively compared with stock implants. Early postoperative pain tended to favor stock implants, while intermediate follow-up favored PSI. Long-term dietary outcomes showed no consistent superiority of either implant system. Overall, PSI provided selective functional benefits, particularly in long-term mobility.

4.2. Study II. – Comparative efficacy of patient-specific versus hand-molded implants in cranioplasty

A total of 125 studies with more than 10,000 patients were analyzed. PSI were associated with shorter operative times, lower reoperation and explantation rates, and superior cosmetic outcomes compared with HM implants. SSI rates were comparable between implant types. Material-specific analyses showed particularly favorable outcomes for calcium phosphate–titanium and hydroxyapatite PSI.

5. Conclusions

5.1. Study I. – Comparative efficacy of patient-specific and stock implants in temporomandibular joint replacement

Patient-specific TMJ implants offer a significant long-term improvement in mouth opening, while pain and dietary outcomes vary over time. Implant selection should therefore be individualized based on functional goals and patient characteristics.

5.2. Study II. – Comparative efficacy of patient-specific versus hand-molded implants in cranioplasty

In CP, PSI demonstrate clear advantages in surgical efficiency, durability, and aesthetic outcomes without increasing infection risk. HM implants remain a viable option in selected clinical and resource-limited settings.

5.3. Overall Conclusion

This PhD thesis supports personalized medicine as a targeted, indication-driven strategy in maxillofacial surgery. PSI provide meaningful benefits in anatomically complex reconstructions, while conventional implants remain effective alternatives in less demanding scenarios. Evidence-based patient selection is essential for optimal integration of personalized implant technologies into clinical practice.

6. Bibliography

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