EFFECTS OF BIOMATERIALS AND PROSTHETIC DESIGN ON PERI-IMPLANT HARD AND SOFT TISSUE HEALTH

PhD Thesis Booklet

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1. INTRODUCTION

1.1. Overview of the topic

1.1.1. What is the topic?

Investigating monolithic zirconia and metal-ceramic implant-supported SCs and evaluating short and long implant-abutment designs.

1.1.2. What is the problem to solve?

There is an unmet need for statistical analysis comparing the gold-standard metal-ceramic with the newer monolithic zirconia implant crowns, and conflicting data exist regarding the outcomes of using long and short implant abutments.

1.1.3. What is the importance of the topic?

This topic dives into the latest advancements in dental materials and prosthetic designs, focusing on how they impact treatment outcomes. By examining new materials, we gain valuable insights into ways to enhance durability, aesthetics, and biocompatibility in implant-supported restorations, especially with the integration of digital technologies. Addressing challenges in this area holds the potential to refine clinical decision-making, promoting long-term stability and function for many patients. Ultimately, these findings could help raise the standards of care in implant prosthodontics.

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

Our findings could guide clinical practices in implant prosthodontics, particularly in material selection for implant-supported restorations, ultimately improving patient outcomes. Additionally, the research may provide insights into the success rates associated with different implant-abutment lengths, offering evidence-based recommendations for clinicians. These insights have the potential to refine implant treatment protocols, reduce complications, and enhance long-term success rates in implant dentistry.

2. OBJECTIVES

2.1. Study I – Investigating the potential benefits of using monolithic zirconia over metal-ceramic as implant-supported single crowns

A few studies have investigated monolithic zirconia implant-supported SCs compared with other materials, but no quantitative analysis has been conducted with the gold standard metal-ceramic crowns. Therefore, our aim was to conduct a systematic review and meta-analysis evaluating monolithic zirconia and metal-ceramic implant-supported SCs.

2.2. Study II – Investigating the influence of abutment height on crestal bone stability and peri-implant soft tissue health

Current literature evidence is inconclusive whether the height of the implant abutment influences the health of the peri-implant tissues. We aimed to investigate the effect of abutment height on crestal bone stability and peri-implant soft tissue health with the highest evidence-level methodology.

3. METHODS

Our systematic reviews and meta-analyses were reported according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) 2020 Statement. The review protocols were registered on PROSPERO (Study I: CRD42021285227; Study II: CRD42022331923), and the Cochrane Handbook's recommendations for Systematic Reviews of Interventions Version 6.1.0 were followed.

3.1. Literature search and eligibility criteria

A systematic search was conducted across five medical databases: MEDLINE (PubMed), EMBASE, Web of Science, CENTRAL, and Scopus.

For inclusion, studies must be RCTs, human studies with at least 20 patients treated, and have a follow-up period of at least 1 year after restoration insertion. The studies needed to provide precise details on the restoration material used (monolithic zirconia, minimally or micro-veneered zirconia with veneering ceramics only on non-functional areas, metal-ceramics) and clearly describe the type of restoration (cement- or screw-retained, one-piece or two-piece, SC). Additionally, any brands and types of titanium implants used, and thorough reporting of clinical outcomes were required for Study I.

For Study II, the following criteria had to be fulfilled: human studies with at least 20 participants, a follow-up period of at least 6 months, any brand and type of titanium, bone-level or platform-switching (PS) implants, detailed reporting of biological outcomes, and detailed reporting of abutment height (short abutments <2 mm and long abutments ≥2 mm) with fixed single or partial restorations (up to 3-unit restorations).

3.2. Study selection and data collection

The publications found through the searches were imported into a reference management software, EndNote X9 (Clarivate Analytics, Philadelphia, PA, USA).

Two reviewers screened the records by title and abstract, resolving any disagreements through discussion. They independently assessed the full texts of the selected studies and examined reference lists for additional potential studies. Cohen's Kappa coefficient was calculated to assess agreement at both stages. Any remaining disagreements were resolved by a third reviewer.

Two authors independently extracted data from the selected articles.

3.3. Quality assessment

The quality of each included study was independently assessed by two reviewers using the Cochrane Risk of Bias Tool 2 for RCTs and the ROBINS-I tool for non-randomized studies. A third reviewer was involved if necessary to resolve any disagreements.

The certainty of the evidence was evaluated using the GRADE approach.

3.4. Data synthesis and analysis

Data synthesis and statistical analysis were conducted following guidelines from the Cochrane Collaboration and established meta-analysis practices.

For continuous outcomes like MBL and PPD, the pooled mean difference (MD) with 95% confidence intervals (CI) was calculated using extracted sample sizes, means, and standard deviations (SD). For categorical outcomes like BOP, pooled odds ratios (OR) or risk ratios (RR) with 95% CI were computed using the Mantel-Haenszel method. The restricted maximum-likelihood (REML) estimator was applied for continuous outcomes, while the Hartung-Knapp adjustment was used for random-effects meta-analysis to reduce false positives.

Where SDs were unavailable, they were conservatively estimated. In cases with inconsistent implant and patient numbers, intracluster correlation coefficients (ICC) were used to adjust sample sizes for potential within-patient correlations. Adjustments were performed using design effects based on cluster sizes and ICC values of 0 (indicating independence) and 1 or 0.5 (indicating varying levels of dependence). For studies involving multiple interventions in the same subjects, these ICC-based corrections were also applied, and results for different ICC values were presented for comparison.

Statistical heterogeneity was evaluated using Cochrane's Q test and Higgins' I^2 statistic. τ^2 was estimated using REML, and its confidence interval was calculated via the Q profile method. Due to the limited number of studies, publication bias was not assessed.

Forest plots visually summarized effect sizes, and all analyses were performed using R with the *meta* and *dmetar* packages.

4. RESULTS

4.1. Study I

4.1.1. Marginal Bone Loss

Three studies with 168 implant-supported SCs revealed 0.11 mm less bone loss around monolithic zirconia restorations compared to metal-ceramic restorations over 1 year (MD –0.11 mm, 95% CI: [–0.25; 0.03], P=0.61). This difference was not statistically or clinically significant. Results were consistent across studies (I^2=0%), with moderate evidence certainty.

4.1.2. Bleeding on Probing

Analysis of 168 implant-supported SCs showed 34% lower odds of BOP in monolithic zirconia restorations compared to metal-ceramic restorations over 1 year (OR 0.66, 95% CI: [0.25; 1.79], P=0.90). This difference was not significant, with consistent results across studies (I^2=0%) and moderate evidence certainty.

4.1.3. Chipping

Four studies with 237 SCs initially showed a 67% lower odds of chipping in monolithic zirconia restorations compared to metal-ceramic restorations over 1 year (OR 0.33, 95% CI: [0.07; 1.58], P=0.44). Excluding an outlier study reduced heterogeneity, and the revised analysis (187 SCs) demonstrated an 83% reduction in chipping odds for monolithic zirconia (OR 0.17, 95% CI: [0.03; 0.99], P=0.87). Evidence certainty was moderate, with consistent results (I^2=0%).

4.1.4. Implant Failure

All four studies, covering 240 implants, showed no significant difference in implant failure between monolithic zirconia and metal-ceramic restorations over 1 year (OR 1.30, 95% CI: [0.24; 7.08], P=0.96). Results were consistent (I^2=0%), with moderate evidence certainty.

4.2. Study II

4.2.1. Marginal Bone Loss at 6 months

Three studies (174 implants) showed 0.63 mm less MBL in the long abutment group (MD 0.63, 95% CI: [–0.16; 1.42], $p<0.001$). Evidence certainty was moderate, with high heterogeneity ($I^2=93.99\%$).

4.2.2. Marginal Bone Loss at 1 year

Six studies (384 implants) demonstrated 0.26 mm less MBL in the long abutment group (MD 0.26, 95% CI: [–0.02; 0.53], $p=0.002$). Evidence certainty was high, with moderate heterogeneity ($I^2=73.25\%$). A subgroup analysis found no significant difference in MBL when definitive abutments were placed immediately after implant placement. Excluding one study and focusing on RCTs yielded similar results (MD 0.26, 95% CI: [–0.12; 0.65], $I^2=77\%$).

4.2.3. Bleeding on Probing

Four studies (256 implants) found no significant difference in BOP between abutment heights at 1 year (RR 0.97, 95% CI: [0.76; 1.23], $p=0.927$). Evidence certainty was moderate, with no heterogeneity ($I^2=0\%$).

4.2.4. Probing Pocket Depth

Two studies (154 implants) found no significant difference in PPD between abutment heights at 1 year (MD –0.05, 95% CI: [–1.11; 1.01], $p=0.650$). Evidence certainty was moderate, with no heterogeneity ($I^2=0\%$).

5. CONCLUSION

5.1. Study I

At the one-year follow-up, monolithic zirconia and metal-ceramic restoration types demonstrated similar outcomes concerning MBL, BOP, survival, and failure rates. However, monolithic zirconia exhibited significantly less chipping than metal-ceramic restorations over the same period. Based on the current studies, monolithic zirconia is a valid alternative for implant-supported SCs in the short term with less technical complications. Nonetheless, additional research is essential to confirm the long-term clinical performance of monolithic zirconia single implant crowns.

5.2. Study II

Longer abutments on bone-level implants appear to be a favorable treatment option for reducing early MBL. While the timing of abutment connection may not significantly influence biological outcomes over a short-term follow-up period, further studies are necessary to validate these findings and explore their implications for long-term clinical practice.

6. BIBLIOGRAPHY OF THE CANDIDATE'S PUBLICATIONS

Publications related to the thesis

Tajti P, Solyom E, Czumbel LM, Szabó B, Fazekas R, Németh O, Hermann P, Gerber G, Hegyi P, Mikulás K. (2023) Monolithic zirconia as a valid alternative to metal-ceramic for implant-supported single crowns in the posterior region: A systematic review and meta-analysis of randomized controlled trials. **J Prosthet Dent**. Online ahead of print.

D1, IF: 4.30

Tajti P, Solyom E, Váncsa S, Mátrai P, Hegyi P, Varga G, Hermann P, Borbély J, Sculean A, Mikulás K. (2024) Less marginal bone loss around bone-level implants restored with long abutments: A systematic review and meta-analysis. **Periodontol 2000**, 94: 627-638.

D1, IF: 17.50

Publications not related to the thesis

Szalai E, **<u>Tajti P</u>**, Szabó B, Kói T, Hegyi P, Czumbel LM, Varga G, Kerémi B. (2023) Organoleptic and halitometric assessments do not correlate well in intra-oral halitosis: a systematic review and meta-analysis. **J Evid Based Dent Pract**, 23: 101862.

Q1, IF: 3.6

Szalai E, **<u>Tajti P</u>**, Szabó B, Hegyi P, Czumbel LM, Shojazadeh S, Varga G, Németh O, Kerémi B. (2023) Daily use of chlorine dioxide effectively treats halitosis: A meta-analysis of randomised controlled trials. **PLoS One**, 18: e0280377.

Q1, IF: 3.752

<u>Tajti P</u>, Gerber G, Hermann P, Schmidt P. (2023) Complex rehabilitation of erosive tooth wear with digital workflows. **Fogorvosi Szemle** 116: 168-174.

Q4

Radoczy-Drajko Zs, Windisch P, Svidro E, **<u>Tajti P</u>**, Molnar B, Gerber G. (2021) Clinical, radiographical and histological evaluation of alveolar ridge preservation with an autogenous tooth derived particulate graft in EDS class 3–4 defects. **BMC Oral Health** 21: 63.

Q1, IF: 2.6