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Dagmar Ríos

In patients undergoing implant-supported rehabilitation, do zirconia abutments influence marginal bone and soft tissue behavior differently compared with titanium abutments? Systematic Review of Literature

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Dissertação apresentada a Faculdade ILAPEO como parte dos requisitos para obtenção de título de Mestre em Odontologia com área de concentração em Implantodontia

Orientadora: Profa. Dra. Ana Cláudia M. Melo Toyofuku

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Dedicatória

To my parents, Digna and Luis Ríos, for being my fundamental pillar, my guide, and the living example of perseverance. Thank you for believing in me at every stage of this journey, for your unconditional love, and for teaching me that with hard work, no goal is out of reach. This achievement is as much yours as it is mine.

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Sumário

1. Artigo científico

Artigo de acordo com as normas da Faculdade ILAPEO, para futura publicação no periódico **Journal of Oral Innovation and Science (JOIS).**

IN PATIENTS UNDERGOING IMPLANT-SUPPORTED REHABILITATION, DO ZIRCONIA ABUTMENTS INFLUENCE MARGINAL BONE AND SOFT TISSUE BEHAVIOR DIFFERENTLY COMPARED WITH TITANIUM ABUTMENTS? SYSTEMATIC REVIEW OF LITERATURE.

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RESUMO

Objetivo: Avaliar o impacto dos pilares de zircônia nos níveis ósseos marginais e no comportamento dos tecidos moles peri-implantares em reabilitações implanto-suportadas, em comparação com pilares de titânio. Materiais e Métodos: Esta revisão sistemática seguiu as diretrizes PRISMA e foi baseada na estratégia PICO. Foi realizada uma busca abrangente em múltiplas bases de dados e literatura cinzenta, identificando 3.750 registros. Após a remoção de duplicatas, 2.189 estudos foram triados, e 82 artigos em texto completo foram avaliados quanto à elegibilidade. Treze estudos atenderam aos critérios de inclusão e foram incluídos na síntese qualitativa. Resultados: Os estudos incluídos demonstraram que pilares de zircônia e titânio apresentaram resultados comparáveis em relação às alterações nos níveis ósseos marginais e às condições dos tecidos moles peri-implantares. Embora os pilares de zircônia possam oferecer melhores resultados estéticos, especialmente em casos com mucosa peri-implantar fina, não há evidência consistente de sua superioridade na manutenção da saúde peri-implantar. Conclusão: Os pilares de zircônia representam uma alternativa viável aos pilares de titânio, apresentando resultados clínicos e biológicos semelhantes. No entanto, as evidências atuais não demonstram vantagens claras em relação ao titânio quanto à preservação óssea marginal ou ao comportamento dos tecidos moles, ressaltando a necessidade de estudos clínicos bem delineados.

Palavras-chave: Intermediário de Zirconia; Intermediário de Titânio; Nível ósseo marginal; Tecidos peri-implantares; Revisão sistemática.

ABSTRACT

Objective: To evaluate the impact of zirconia abutments on marginal bone levels and peri-implant soft tissue behavior in implant-supported rehabilitations compared to titanium abutments. Materials and Methods: This systematic review followed PRISMA guidelines and was based on the PICO framework. A comprehensive search was conducted across multiple databases and gray literature, identifying 3,750 records. After duplicate removal, 2,189 studies were screened, and 82 full-text articles were assessed for eligibility. Thirteen studies met the inclusion criteria and were included in the qualitative synthesis. Results: The included studies demonstrated that zirconia and titanium abutments showed comparable outcomes regarding marginal bone level changes and peri-implant soft tissue conditions. While zirconia abutments may offer improved esthetic outcomes, particularly in cases with thin peri-implant mucosa, no consistent evidence supports their superiority in maintaining peri-implant health. Conclusion: Zirconia abutments appear to be a viable alternative to titanium abutments, providing similar clinical and biological outcomes. However, current evidence does not demonstrate clear advantages over titanium in terms of marginal bone preservation or soft tissue behavior, highlighting the need for further well-designed clinical studies.

Keywords: Zirconia abutments; Titanium abutments; Marginal bone level; Peri-implant tissues; Systematic review.

INTRODUCTION

Since the introduction of osseointegration, the replacement of missing teeth by implants has become a predictable treatment modality for both complete and partial edentulous patients.[1] Implants have evolved significantly to ensure biocompatibility, harmonize with adjacent soft and hard tissues, and improve both esthetic and biomechanical outcomes. The implant abutments serve as the critical link between the implant body and implant-supported restorations, and a variety of materials and fabrication techniques have been developed to address different clinical situations. Prefabricated titanium abutments are the most commonly used due to their simplicity and cost-effectiveness.[2]

Nevertheless, bone loss may negatively influence the soft tissue topography and the esthetic outcome of implant surgery. Radiographic analysis has shown that the largest amount of bone loss occurs following implant placement and abutment connection.[3] The abutment is a transmucosal component that connects dental implants to prostheses, allowing for masticatory loading transmission. At the same time, it is the key component that protects the implants from the contaminated oral environment.[4] The collar region of the implant and the connection zone

of the implant to the abutment seem to be important for the maintenance of the marginal bone levels. Similar to the crown margins in natural teeth, the biological width should not be violated.[5]

The use of zirconia as a material for implant abutments has been increasingly widespread, for its white color, different from titanium abutments, and for its high level of biocompatibility.[6] Also, zirconium abutments offer a much better esthetic outcome, especially in thinner peri-implant mucosa cases.[7] In addition, some studies claim zirconium to be the most bio-compatible material with lower adhesion of bacteria.[8-10] Zirconia is five times harder than titanium according to the Knoop hardness scale and has been suggested to cause more wear on the implant head, potentially leading to a greater misfit compared to titanium abutments. Laboratory studies have demonstrated that zirconia abutments can produce more initial and total wear at the implant abutment interface.[11]

Given the ongoing lack of consensus in the literature regarding the clinical advantages of zirconia abutments, this systematic review aims to critically evaluate their impact on marginal bone levels and peri-implant soft tissue behavior in implant-supported rehabilitations.

MATERIALS AND METHODS

This systematic review followed the guidelines of the Preferred Reports List for Systematic Reviews and Meta-analysis (PRISMA), considering the following PICO question:

P: Patients receiving implant-supported restorations

I: Zirconia abutments

C: Titanium abutments

O: Marginal bone level changes and peri-implant soft tissue outcomes

Search Strategy:

The search strategy is presented on Table 1.

Table 1: Search Strategy.

Base	Search
PUBMED	Dental Implants [Mesh] OR Dental implant OR Dental implants OR Implant Supported Prosthesis OR Implant supported protheses AND Dental Abutments [Mesh] OR Abutment OR Abutments OR component OR Pilar AND Zirconia OR Zirconio AND soft tissues OR soft tissue AND Marginal bone loss
COCHRANE	Dental implant OR Dental implants OR Implant Supported Prosthesis OR Implant supported protheses AND Dental Abutments OR Abutment OR Abutments OR component OR Pilar AND Zirconia OR Zirconio AND soft tissues OR soft tissue AND Marginal bone loss
GOOGLE SCHOLAR	Dental Implants [Mesh] OR Dental implant OR Dental implants OR Implant Supported Prosthesis OR Implant supported protheses AND Dental Abutments [Mesh] OR Abutment OR Abutments OR component OR Pilar AND Zirconia OR Zirconio AND soft tissues OR soft tissue AND Marginal bone lo
WEB OF SCIENCE	“Implant Supported Prosthesis” OR ” Implant Supported Prostheses” AND “Dental Abutment“ OR Abutment AND Zirconia AND “soft tissues” AND “Marginal bone loss” (All Fields)
SCOPUS	"Dental Implants" OR "Dental implant" OR "Dental implants" OR "Implant Supported Prosthesis" OR "Implant supported protheses" AND "Dental Abutments" OR abutment OR abutments OR component OR pilar AND zirconia OR zirconio AND "soft tissues" OR "soft tissue" AND "Marginal bone loss"
LILACS	(prótese dentária fixada por implante) AND (pilar de zirconia) AND (perda óssea)

Study Selection:

After the electronic search was performed by two authors (A.S.M and D.R), and the selection of eligible papers was carried out in two phases. In phase 1, two reviewers independently read the titles with their abstracts (R1: D.R. and R2: A.C.M.M.) and, if the inclusion criteria were met, the papers were selected. The selected studies were compared by reviewers to reach a consensus. Two experts (R.A.V and P.R.A.) were consulted in the event of disagreement between the titles and abstracts selected by reviewers 1 and 2. In phase 2, all

selected papers were fully read and included or excluded according to the eligibility criteria. In this phase, reviewers 1 and 2 to reach a consensus in order to include eligible papers.

Eligibility Criteria:

Inclusion criteria: Randomized clinical trials and observational studies that assessed bone and soft tissues response when zirconia abutments are used. Studies were included if in English, Portuguese or Spanish language, with no publication date restrictions and with a minimum of six months of follow-up after the surgical procedure.

Exclusion criteria:

1. Narrative or Systematic literature review, letter, personal opinion, book chapter, conference abstract
2. Case report article
3. Preclinical studies
4. Zirconio Implants or different materials framework
5. Absence of bone measurements or soft tissue evaluation
6. Absence of information about abutment material
7. Nonadult patients (< 18 years)
8. Paper in language different from English, Spanish or Portuguese
9. Unrelated theme

Data collection:

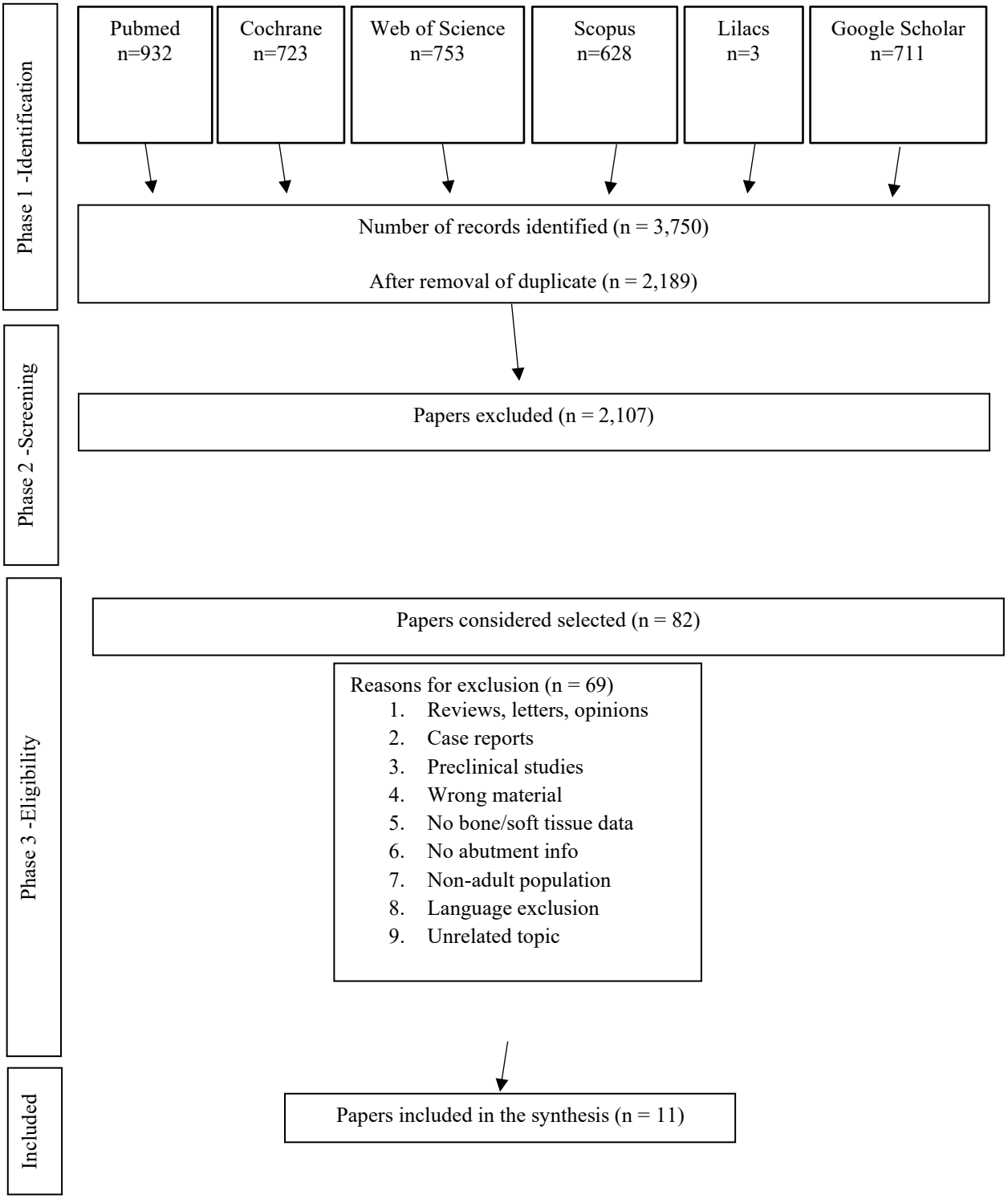
The collected data were registered in a table with the main points of interest of each study: Author/year; Study design; n (implants/patients); Implant design; Area; Abutment type; Single, partial or complete rehabilitation; Opposing arch (Antagonist); Survival/Success;

Follow-up; Marginal bone lossSoft tissues; Pocket probing depth; Plaque index; Bleeding on probing; Mechanical complications; Biological complications; Main Conclusion.

RESULTS

In phase 1, according to the search strategy that was carried out, 3,750 papers were included from databases and gray literature (Pubmed: 932, Cochrane: 723, Web of Science: 753, Scopus: 628, Lilacs: 3, Google Scholar: 711). Once duplicate studies were removed, 2,189 references remained. After reading their titles and abstracts, 82 references were included for full reading. Afterwards, the eligible papers were selected according to the inclusion and exclusion criteria. Thirteen papers were considered eligible. Figure 1 shows a flowchart of the search process, identification and inclusion of references.

Table 1: Flowchart of the search process.



The data collected are shown in table 2. Table 2: Summary of the descriptive results of the selected studies

Author/year	Study design	n (implants/patients)	Implant design/trade name	Area	Abutment type	Single, partial or complete rehabilitation	Survival/Success	Follow-up	Marginal bone loss	Soft tissues	Pocket probing depth	Plaque index	Bleeding on probing	Mechanical complications	Biological complications	Conclusion
Vanlıog˘lu, et al.[12], 2012	Prospective cohort study	23implants/12 patients	Straumann® Narrow Neck Solid Screw implants (Straumann AG, Basel, Switzerland) and Astra Tech® MicroThread implants (Dentsply Sirona, Mölndal, Sweden)	Maxillary lateral incisor	Custom-made zirconia abutments and prefabricated metal abutments	Single	100%	5 years	Mean marginal bone loss of 0.21 mm	No data	Probing depth increased from 1.32 to 1.77 mm (Straumann, custom abutments) and from 1.29 to 1.87 mm (Astra, custom abutments) at 5 years; prefabricated abutments showed 1.79 mm (Straumann) and 1.89 mm (Astra), with no significant differences between groups.	Plaque-free patients decreased from 4 to 2 (Straumann) and from 3 to 2 (Astra) over 5 years, with no high plaque scores (2–3) reported.	No data reported	In one patient, screw loosening was observed at the 1-year recall.	No signs of infection, pain, or soft tissue reactions; peri-implant tissues showed favorable conditions, indicating excellent biocompatibility.	Custom-made zirconia abutments provided sufficient stability to support all-ceramic restorations on narrow implants in anterior regions over a 5-year period.
Ferrari et al.[6], 2015	Randomized clinical trial	97/47	OsseoSpeed ™ TX tapered implant (Dentsply Sirona Implants, Mölndal, Sweden)	Anterior maxilla	Titanium nitride abutments (n=18), titanium abutments (n=15), and zirconia abutments (n=14)	Single	No data	2 years	Marginal bone change was 0.42 mm (Group 1, titanium), −0.48 mm (Group 2, titanium nitride), and −0.57 mm (Group 3, zirconia).	No data	Probing depth was 1.81 ± 0.82 mm at 1 year and 1.85 ± 0.82 mm at 2 years.	No data	No data	Zirconia abutments showed significantly lower fracture strength compared to titanium abutments.	No biological complications	Abutment type (titanium, titanium nitride, zirconia) did not influence peri-implant outcomes at 2 years; no association was found with biotype, and zirconia abutments did not improve soft tissue conditions.
Den Hartog et al.[13],2016	Randomized clinical trial	62/62	NobelReplace® Tapered Groovy implant (Nobel Biocare, Zürich, Switzerland)	Anterior maxilla (I, C or 1st PM)	Customized Zirconia abutment	Single	96.3% immediate group/100% conventional group	5 years	Mesial and distal combined MBL: 1.16 ± 0.93 mm (immediate) vs 1.20 ± 1.10 mm (conventional).	PES was 7.1 ± 1.5 (immediate) vs 6.5 ± 1.6 (conventional) at baseline, and 7.2 ± 1.5 vs 6.8 ± 1.3 at 5-years.	PD (mesial/distal/midfacial) — Baseline: 3.07/3.37/2.78 mm (immediate) vs 3.03/3.50/3.07 mm (conventional); T5: 2.76/3.04/2.92 mm vs 3.31/3.19/3.15 mm, respectively.	All implants in both groups have a score of 0	BOP at 5-yeras: Immediate: no bleeding 42.3%, isolated 46.2%, confluent 11.5%, profuse 0%; Conventional: 40.7%, 40.7%, 18.5%, 0%, respectively.	One implant was lost 3 weeks after immediate loading; veneering fractures occurred in 2 conventional and 1 immediate case.	Peri-implantitis was more frequent in the conventional group (4 cases) than in the immediate group (2 cases).	Immediate loading in the anterior zone is non-inferior to conventional loading.

Slagter et al.[14], 2016	Randomized clinical trial	40/40	NobelActive® implants (Nobel Biocare, Zürich, Switzerland)	Anterior maxilla (I, C or 1st PM)	Customized Zirconia abutment	Single	100% survival rate	1 year	• MBL (mesial/distal): -0.56/-0.74 mm (immediate) vs -0.51/-0.54 mm (delayed), with no significant differences ($p > 0.5$).	IML and MML showed no significant changes at 1 year in either group.	PD at 1 year was not significantly different from baseline: Immediate 3.3 (M), 3.5 (D), 3.2 (B), 2.7 (P) mm; Delayed 3.6 (M), 3.8 (D), 3.3 (B), 3.1 (P) mm.	Remained low throughout the follow-up in both groups.	Remained low throughout the follow-up in both groups.	No data	One delayed-placement patient developed a small bone sequestrum requiring removal.	Immediate placement with delayed provisionalization is non-inferior to delayed placement for MBL change (>0.9 mm) in ≥5 mm labial defects at 1 year.
Thoma et al.[15], 2018	Randomized controlled clinical trial	33/33	Straumann® two-piece implants (3.3 or 4.1 mm; Institut Straumann AG, Basel, Switzerland)	Anterior maxilla and mandible	Two groups: Cemented lithium disilicate crown on a customized zirconia abutment (CEM) or a screw-retained crown with a directly veneered zirconia abutment (SCREW).	Single	100% survival rate	6 months	Median MBL changes were minimal: 0.31–0.32 mm (CEM) and 0.47–0.36 mm (SCREW).	No data	Median PD at 6 months: 2.89 mm (IQR 2.25–3.00) for implants vs 2.25 mm (IQR 2.13–3.18) for adjacent teeth.	Median PCR at 6 months: 13% (IQR 8–19) for implants vs 9% (IQR 7–17) for adjacent teeth.	Median BOP at 6 months: 17% (IQR 4–50) for implants vs 17% (IQR 0–33) for adjacent teeth.	Minor chipping and a cementation gap occurred in the cemented group, while no mechanical complications were reported in the screw-retained group at 6 months.	CEM showed higher inflammatory cell counts and periodontal pathogens than SCREW, with no significant differences in clinical outcomes at 6 months.	Cemented reconstructions showed higher inflammatory cells and pathogen prevalence, while both groups had similar MBL, BOP, and PD outcomes.
Schnider et al.[16], 2018	Prospective Cohort	50/41	Straumann® Bone Level implants (Institut Straumann AG, Basel, Switzerland)	Anterior and premolar area	CARES Zirconium dioxide	Single	100% survival and succes	2 years	Implants were placed ~1.0 mm subcrestally (-0.95 mm; 95% CI -2.39 to 0.48), with 1.01 mm bone remodeling at follow-up.	All implants had ≥1 mm of keratinized mucosa, with 50% presenting 3 mm width.	PD: 97% ≤4 mm, 2% at 5 mm, and 1% at 6 mm.	PI 12.7%,	BOP was 8.3%, indicating healthy peri-implant tissues.	No mechanical complications where observed	No biological complications where observed	Screw-retained crowns on veneered CAD/CAM zirconia abutments with CrossFit connection show promising outcomes for anterior and premolar tooth replacement.
Mangano et al.[17], 2019	Retrospective Study	40/25	Morse-taper connection implants (Exacone®, Leone Implants, Italy)	Posterior areas (premolars and molars) of both arches.	Zirconia abutments cemented on different titanium bases (8 Tibase®, 10 Multitech® straight, and 12 Multitech® angled 15),	Single	97.5%.	1 year	No data	No data	No data	No data	No data	Mechanical complications included: 1 abutment–implant connection loss, 1 zirconia–Ti-base decementation, and 1 crown–abutment decementation.	No biological complications	Single Morse-taper implants with monolithic zirconia on customized hybrid abutments (full-digital workflow) showed 97.5% survival and 92.4% success at 1 year.

Kahramanoglu et al.[18], 2019	Prospective Cohort Study	29/24	CAMLOG® Screw-Line Promote Plus implant (Camlog Biotechnologies AG, Basel, Switzerland)	Maxilla (10 CI, 9 LI, 2 C, and 8 1st PM)	Ceramic abutment	Single	100%	3 years	MBL increased from 0.12 ± 0.13 mm (6 months) to 0.47 ± 0.75 mm (3 years).	No data	Mean PD increased from 2.82 ± 0.60 mm (baseline) to 3.06 ± 0.88 mm at 3 years.	PI increased from 0.02 ± 0.01 (baseline) to 0.29 ± 0.60 at 3 years.	BOP increased from 0.07 ± 0.26 (baseline) to 0.31 ± 0.47 at 3 years.	No mechanical complications	No biological complications	Early-loaded maxillary anterior implants showed successful clinical and radiographic outcomes at 3 years.
Fonseca et al.[19], 2021	Prospective cohort study	40/32	bone level SLActive de Straumann AG, con conexión NC (Narrow Crossfit®) o RC (Regular Crossfit®)	Anterior maxilla and mandible	Customized Zirconia	Single	100% implant survival rate and a 97.5% prosthetic	6 years 7 months	PIBL was highest at placement (0.99 ± 0.79 mm), decreased before prosthetic delivery, and stabilized after loading; at second follow-up it was 0.82 ± 1.18 mm, with an overall change of 0.17 mm.	No peri-implantitis; ≥3 mm buccal keratinized mucosa in 98.4% of sites.	PD ≤4 mm in 98.7% of the sites and 5 mm in 1.3% of the sites,	PI in 25.1% of the sites	observed in 10.7% of all sites	One abutment fracture occurred at the maxillary right second premolar after 7 years.	No biological complications	Screw-retained crowns on veneered CAD/CAM zirconia abutments with conical connection showed very good clinical performance at 6.6 years, supporting use in anterior and premolar sites.
Salem et al.[20], 2022	Prospective study	30/30	V-Plus® (Vitronex Elite Implant)	1str and 2nd maxillary premolars	Customized zirconia (Groups: Z - ultrahigh-translucent monolithic zirconia (Nacera Pearl Q3); C -resin-matrix ceramic (Cerasmart); P - PEKK (PEKKTON) with composite veneering (Crea.lign).	Single	100%	2 years	At 18-24 months, MBL ranged from 0.9–1.1 mm (mesial) and 1.1–1.3 mm (distal) across groups.	No data	PPD at 24 months: 1.8 mm (1.5–2.0) in Group Z and 2.0 mm (1.5–2.0) in Groups C and P.	PI score was 1 in all groups at 2 years, with no significant intergroup differences.	mSBI (median, range): Z 1 (1–2), C 1.5 (1–2), P 2 (1–2); significant intergroup difference ($p = 0.002$).	One crown decementation occurred in Group C (requiring re-cementation) and one veneer chipping in Group P (requiring intraoral repair).	No biological complications	All crown systems showed successful outcomes, with ultrahigh-translucent zirconia performing best and PEKK composite worst; survival/success rates and marginal bone loss were comparable among groups.

Ayyadanveettil et al.[21] 2022	Randomized clinical trial	40/40	blueSKY® implants (bredent medical GmbH & Co. KG, Senden, Germany)	Anterior and posterior area - maxilla	1. PEEK (Polyetheretherketone) Abutments 2. Zirconia Abutments	Single	survival 100%	5 years	No significant differences in mesial or distal bone levels between PEEK and zirconia groups at 5 years.	Favorable tissue response	PPD: 2.32 ± 0.50 mm (ZIR) vs 2.13 ± 0.60 mm (PEEK); control teeth: 2.10 ± 0.30 mm (ZIR) and 1.77 ± 0.51 mm (PEEK).	PCR: 0.19 ± 0.19 (ZIR) vs 0.15 ± 0.17 (PEEK); control teeth: 0.22 ± 0.20 (ZIR) and 0.21 ± 0.19 (PEEK).	BOP: 0.12 ± 0.11 (ZIR) vs 0.08 ± 0.12 (PEEK); control teeth: 0.13 ± 0.15 (ZIR) and 0.08 ± 0.12 (PEEK).	No fractures, restoration loss, or abutment screw loosening were reported in either group.	Both materials showed excellent biocompatibility, favorable tissue response, low plaque, and stable bone levels, supporting their use for single-tooth implant restorations.	Zirconia and PEEK abutments are clinically successful options for esthetic single-tooth implant restorations.

DISCUSSION

The findings of the present review indicate that zirconia and titanium abutments provide comparable outcomes in terms of marginal bone level changes and peri-implant soft tissue behavior. Although zirconia abutments may offer esthetic advantages, particularly in cases with thin peri-implant mucosa, current evidence does not consistently support their superiority in maintaining peri-implant health.

Nevertheless, the analysis of the compiled scientific evidence allows for a continuous evaluation of the clinical and radiographic behavior of ceramic zirconia abutments in single-tooth restorations, contrasting their outcomes in peri-implant health with those of titanium. Beginning with short-term follow-ups, between six months and one year, authors such as Thoma et al.[15] (2018) and Slagter et al.[14] (2016) report 100% survival rates with minimal changes in marginal bone, a finding supported by Mangano et al.[17] (2019) in their one year retrospective study where, utilizing fully digital workflows, they recorded a 97.5% survival rate. Moving into the medium term, fixed between two and three years, Schnider et al.[16] (2018) and Salem et al.[20] (2022) confirm that this 100% success and survival rate is maintained, while Kahramanoğlu et al.[18] (2019) clarify the dynamics of marginal bone loss by demonstrating that the increase in bone loss is primarily concentrated between six months and three years, stabilizing thereafter. This trend toward stabilization is consolidated in long-term studies spanning five to seven years, where Vanlıoğlu et al.[12] (2012) and Ayyıldız et al.[21] (2022) at around five years, and Fonseca et al.[19] (2021) at six and a half years, reaffirm the predictability of zirconia with survival rates remaining at 100%, evidencing that the majority of bone loss occurs prior to prosthetic loading.

This temporal sequence opens the debate on whether the abutment material truly exerts a critical influence on marginal bone loss and soft tissue response compared to titanium. Regarding marginal bone loss, the randomized clinical trial by Ferrari et al.[6] (2015) performs a direct 2 year comparison and determines that the type of material does not significantly influence changes in the crestal bone level, registering very similar losses between titanium and zirconia a conclusion that aligns perfectly with the findings of Ayyıldız et al.[21] (2022), who also found no statistically significant differences at five years. Regarding soft tissue response and pocket probing depth, there is a general consensus on the excellent biocompatibility of zirconia; Vanlıoğlu et al.[12] (2012) highlight the optimal tissue integration of crowns

on customized abutments, although, once again, Ferrari et al.[6] (2015) qualify that zirconia does not statistically improve soft tissue indices or probing depths compared to traditional titanium, maintaining virtually identical health parameters in both groups.

Finally, in examining complications, it is observed that biological or infectious complications are practically non-existent with the use of zirconia as noted by most authors, with the exception of Den Hartog et al.[13] (2016), who mention a higher frequency of peri-implantitis but link it to the loading protocol rather than the material itself. On the mechanical side, zirconia has historically shown lower fracture resistance than titanium, as demonstrated by Ferrari et al.[6] (2015); however, more recent literature by Fonseca et al.[19] (2021) and Salem et al.[20] (2022) indicates that thanks to improvements in internal metallic connections and CAD/CAM designs, current mechanical failure rates are extremely low.

As a general conclusion of the revised literature, it is determined that zirconia abutments are clinically comparable and non-inferior to titanium abutments regarding marginal bone loss, as both materials manage to keep the crestal bone stable over the long term with minimal variations that fall completely within established implant success criteria. Likewise, zirconia offers excellent biocompatibility and integration with the soft tissue, although research demonstrates that it does not provide a statistically significant clinical superiority in tissue health compared to titanium. Therefore, the choice of zirconia is primarily justified by the patient's high aesthetic demands in the anterior sector to avoid grayish shadowing, and by the digital workflow, since from a strictly biological perspective of bone loss and soft tissue response, both materials offer a comparable level of excellence.

CONCLUSION

Zirconia abutments appear to be a viable alternative to titanium abutments, providing similar clinical and biological outcomes. However, current evidence does not demonstrate clear advantages over titanium in terms of marginal bone preservation or soft tissue behavior, highlighting the need for further well-designed clinical studies.

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