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Biomechanical Complications of Implant-Supported Fixed Single Crowns in the Posterior Area: A Systematic Review

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Abstract

Purpose: *The purpose of this systematic review is to identify and explain the biological and mechanical complications of the different types of implant-supported fixed crowns.*

Material and methods: *A database search on PUBMED, COCHRANE and EBSCO were conducted by 2 reviewers for valid articles until Mai 17 2023. The search was led by PICOS formula. The main question was "what are the biomechanical complications pertaining to implant-supported posterior crowns and what caused them? "key-words, inclusion and exclusion criteria were well defined.*

Results: *The preliminary search came up with 108 articles by use of a Boolean-equation. After applying the exclusion criteria, we ended up with 7 full text studies verifying all inclusion criteria. Biological complications percentage reached 11.25%, as for mechanical complications rate it was 11.63%. The study showed a variety of types of biomechanical complications such as bone loss (100%), peri-implant mucositis (16.18%), loss of retention (10.49%), contact points deviation (17.75%), veneering chipping (2.68%). Resin-modified ceramic crowns were the most susceptible to restoration complication, the same a screw-retained Implant-supported posterior crowns.*

Conclusion: *Biomechanical complications can pose challenges to the long-term stability and function of implant-supported posterior crowns. Further research and advancements in implant design and materials will continue to contribute to reducing biomechanical complications and enhancing the success of implant dentistry.*

Introduction

The repair of lost teeth with implant-supported posterior crowns is becoming a popular and effective therapeutic option. In addition to improving looks and usefulness, they also preserve the neighboring tooth structure and it increases the intake of food and nutrients too [1]. Although these restorations have a high percentage of success, biomechanical issues can occasionally occur and may jeopardize their long-term stability and functionality.

The term "Biomechanical complications" refers to problems caused by the interaction of the implant, abutment, and prosthetic parts as well as the forces placed on them during various oral tasks. Implant-supported posterior crowns are under a great deal of stress from the dynamic oral environment's complex and changing stresses. These factors, which may include parafunctional habits and masticatory forces, can affect the restoration's performance and integrity. Understanding the biomechanical complications associated with implant supported posterior crowns is crucial for successful treatment outcomes.

This systematic review aims to analyze and summarize the existing literature on the biomechanical complications of implant-supported posterior crowns by evaluating the factors contributing to these complications, identifying associated risk factors, and discussing failure and survival rate.

Material and Methods

Focused Questions

The main question was "what are the biomechanical complications pertaining to implant-supported posterior crowns and what caused them? "key-words, inclusion and exclusion criteria were well defined.

Constitution of the Work Team and Work Organization

A hospital-university professor of dentistry (DH), an assistant in fixed dental prostheses department (IK). The critical reading of the articles the extraction and data analysis independently, required a commitment from the members of the work team and a well coordination according to predefined schedule.

Literature Research

A database search on PUBMED, COCHRANE and EBSCO were conducted by 2 reviewers for valid articles until Mai 17 2023. The search was led by PICOS formula.

- Population: patients who have benefited from an implant-supported fixed posterior crown
- Intervention: included an implant-supported fixed crown in the posterior area of the patient's arch.
- Comparison: biological and mechanical complications and their different types.
- Outcome: implant-supported posterior crown's complications, survival, success and failure.
- Study design: Randomized clinical trials, controlled clinical studies and cohort studies were included in the collect of data about implant-supported posterior crown's complications, A Systematic Review.

The following MESH terms search terms and their combination were used in the PUBMED search P and I: implant-supported fixed posterior crown C: Biological AND mechanical complications O: Complication OR survival OR success OR failure [MESH Terms] The combination in the builder was set as "P&I AND C AND O" ((Implant supported posterior crowns AND (mechanical OR biological)) AND (survival rate OR failure OR complication OR success)).

Study Selection and Eligibility Criteria

All titles and abstracts of the selected studies were first assessed for the following inclusion criteria:

- Patients who have benefited from an implant-supported fixed posterior crown, in vivo study with a follow up period of at least 1year, randomized clinical trials as well as controlled clinical studies.

Cohort, prospective and retrospective studies

Also, English or French language and studies from 2018 to 2023 were included.

Exclusion Criteria

Articles with invitro, multicentered and pilot studies.

- Finite element analysis, clinical or case report and systematic reviews
- Bridges and anterior crowns as well as studies with a mean follow-up time less than 3 years were also excluded.

The final selection based on inclusion and exclusion criteria was made for the full text articles. This step was again carried out by two readers (Ik) and double checked.

Critical Reading of the Selected Articles and Data Extraction (Reading Grid)

The exclusion criteria and the availability of the text. The relevant data contained in the articles selected in this study were extracted according to a predefined reading grid. The grid was developed by the working group (see appendix) and included the following information's Study design,

Critical Reading of Selected Articles

Titles and abstracts of the research were independently screened by two reviewers (IK) for possible inclusions in the review. The literature on biomechanical complications was independently assessed by three of the reviewers (DH and IK). Any disagreement regarding inclusion was resolved by discussion.

Data Extraction

Data on the following parameters were extracted. Author(s), Title, Journal, Year of publication, Study design (cohort, meta-analysis, randomized controlled clinical trials, prospective case series, prospective study, and prospective clinical study). Population (Planned number of patients, sex, Age), Actual number of patients at the end of the study. Drop-out rate, Mean age, Operators (practitioners), Material framework, Type of used material. Band name of cosmetic mater. Data was extracted independently by two reviewers (Ik) using data extraction form. Disagreement regarding data extraction was resolved by consensus of three reviewers (DH & IK).

Statistical Analysis

The definition of survival is that the implant-supported posterior crown remains intact with or without modification during the observation period Restoration success is the demonstrated ability of restoration to perform as expected without modification Failures included every type of complication that led to the removal or the replacement of the restoration or the loss of biological references such as bone loss as for complication may led or not to a failure

Results

The preliminary search on PUMED using the Boolean-equation had identified 108 articles. The search on Cochrane Central register of Controlled trials had identified the same articles founded by PUBMED search so duplicate was eliminated. During the preselection step, 60 Articles were excluded based on date of release. After reading, additional 24 articles were excluded based on other excluded criteria that we mentioned earlier in the study. Among the 14 selected articles, only 3 corresponded the inclusion criteria cited earlier. Four other studies were included from hand searching.

Among the 7 selected articles 3 Randomized clinical trials, 2 prospective clinical studies, one prospective cohort study and a Medium and long-term retrospective analysis. The articles included are listed in table 1 by author, study type, number of patients and follow-up time (Table I). The 7 studies included different types of restorations and their adhesion type (Cemented or Screw-retained) (Table II) and their incidence in every article. The minimum follow-up period was 1 year (due to lack of data) and the maximum was 10 years. All the picked articles were published in the late 5 years. The different types of implant-supported crowns were mentioned (Table II) by the number of restorations included in every single study.

The articles mentioned the distribution of ISPCs in the posterior area of the arch and it is as follows: 232 premolar (46.03%) and 272 molars (53.97%). (Figure 1). These articles contained

different materials of ISPCs as follows: 276 Metal-ceramic implants, 114 veneered-Zirconia, 85 full-Zirconia, 56 all-Ceramic and 25 Resin modified Ceramic. The number of cement-retained (366 crowns) was approximately the double of the number of screw-retained implants (190 crowns) (Table II). The selected articles had excluded heavy smokers, insufficient oral hygiene, any history of drug abuse, untreated periodontitis, patients in need of significant alveolar bone augmentation, psychological disorders, chronic heart diseases and diabetes and any patient showing TMJ parafunctions (Bruxism) (except Di Francesco et al.'s article).

Table 1: Included articles: their details

Articles	Year of release	Study design	Number of patients	Follow-up period
WOLFART et al .(2)	2021	Randomized clinical trial, prospective study	41 patients (24 females and 17 males), 39 patients completed the study	24 months
Cheng et al(3)	2018	Randomized, controlled clinical trials	38 patients (17 male and 21 female), initially 40 patients	1 year
Di Francesco et al(4)	2022	Medium and long-term retrospective analysis	85 patients (55 males and 30 females)	10 years
CIONCA et al.(5)	2021	Prospective cohort study	34 patients (19 female and 15 male), 31 patients completed the study	6 years
Nielsen et al.(6)	2021	Randomized controlled clinical trial	40 patients (17 males and 23females), 37patients completed the study	1 year
Nielsen et al.(6)	2019	Prospective clinical study	42 patients at the beginning of the study, 11 patients did not complete.	5 years
Augustin-Panadero et al(8)	2019	Prospective clinical study	118 patients(42 male and 76 female)	42 months

Table II: Different types of implant-supported posterior crowns.

Articles	**Total number of restorations**	**Metal-ceramic**	**Full zirconia**	**Veneered Zirconia**	**All ceramic**	**Resin-modified ceramic**	**Resin-modified ceramic**	**Cement retained**
WOLFART et al (2)	56.00	-	-	-	56.00	-	28.00	28.00
Cheng et al(3)	70.00	34.00	36.00	-	-	-	22.00	48.00
Di Francesco et al(4)	172.00	172.00	-	-	-	-	86.00	86.00
CIONCA et al.(5)	49.00	-	49.00	-	-	-	0.00	49.00
Nielsen et al.(6)	45.00	45.00	-	-	-	-	1.00	44.00
Clin Oral Invest(7)	114.00	-	-	114.00	-	-	53.00	61.00
Augustin-Panadero et al(8)	50.00	25.00	-	-	-	25.00	0.00	50.00
Total number of restaurations	556	276	85	114	56	25	190	366

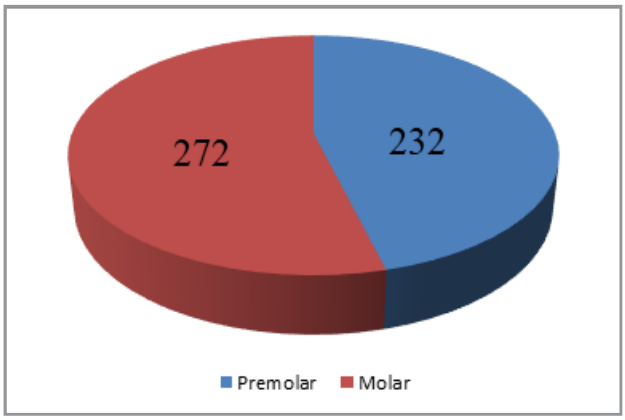

Figure 1: Implant-supported crown's distribution in the posterior area

Restoration Complication, Survival, Failure and Success Rate
Upon analyzing data from every article, the survival rate of all restorations was high with a mean of 98% survival rate. As for the rest, the survival rate was relevantly moderated as it varied from 82.5% to 92.86% (Figure 2). As it is shown in graphic below, the average failure rate was strictly below 20%, thus, the average success and survival rate are strictly over 80% during an average follow-up period of 4 years. The majority of the assessed studies mentioned their survival, failure and success rate except for WOLFART et al.

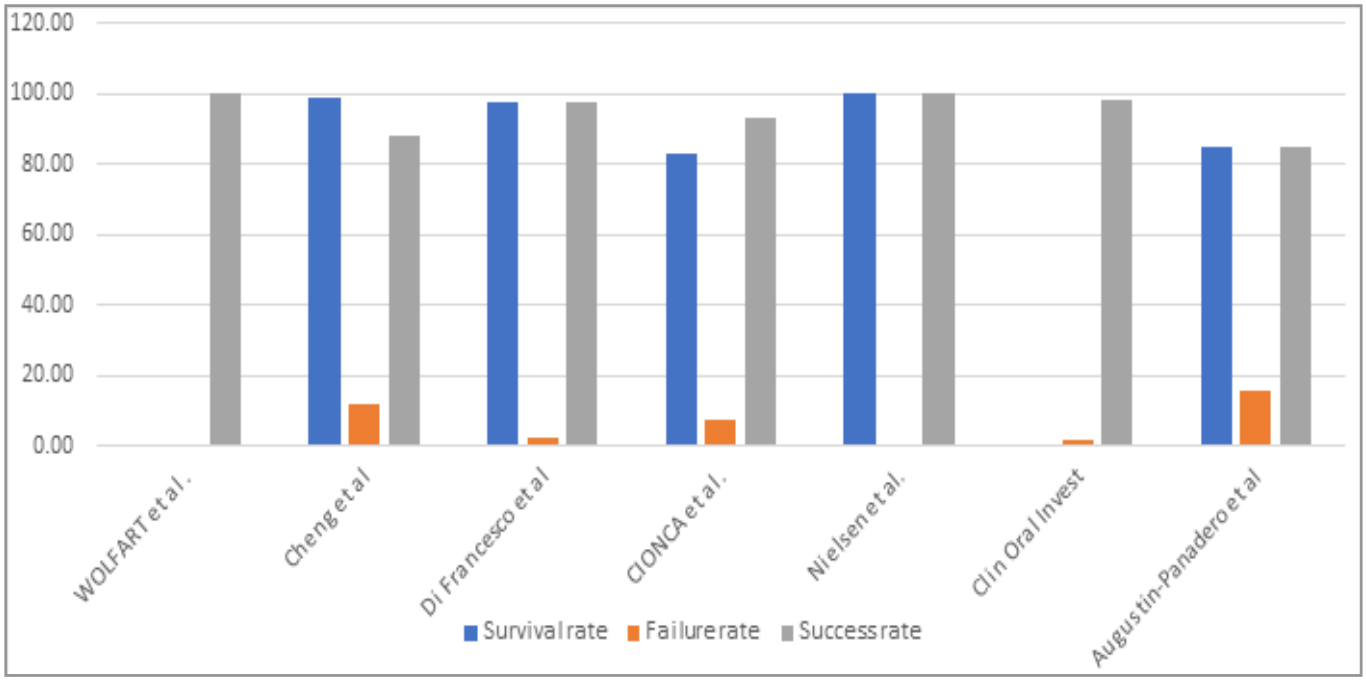

Figure 2: survival, failure and success rate of ISPCs

Biological and Mechanical Complications

Table III display a summary of different types of biological complications and their percentage. Table IV display a summary of different types of mechanical complications and their percentage.

Table V demonstrated the incidence of the biomechanical complications related to screw-retained and cemented ISPCs.

Figure 2 had shown the incidence of the biomechanical complications linked to each type of material of ISPCs.

Biological Complications

The average percentage of biological problems, according to the search, was 11.25% (Table III). The percentage of complications with resin-modified ceramic was 40%, whereas complete zirconia restorations had the lowest percentage at 0.7%. (Figure 2). In comparison to cement-retained crowns, screw-retained crowns had a greater rate of complications (20.92 vs. 14.5%; Table V). Alveolar bone loss is the most frequent biological consequence, occurring in 100% of cases, however the incidence varies depending on the length of follow-up. On the other hand, infection 0.2% and permanent neurosensory dysfunction (which was only cited once in a study) had the lowest proportion. Furthermore, we discovered that the percentages of plaque retention (13.98%), peri-implant mucositis (16.18%), and aseptic loosening (10.2%) were mitigated (Table III). WOLFART et al detected, in the cemented group, cement residues at two restorations (6.9%) (citation)

Mechanical Complications

The average percentage of mechanical complications, according to the search, was 11.36% while its failure rate had reached 2.9% (Table IV). According to figure 2 Resin-modified ceramic had the most complications with 65%, veneered Zirconia took a 37.5%. Whereas full Zirconia has the least mechanical complications of all 2.9%. In comparison to screw-retained ISPCs, cemented ISPCs had the least of mechanical complications13.2%. Screw loosening, Screw fracture, veneering chipping and fracture, loss of retention, abutment, implant and crown fracture, occlusion deviation and approximal contact and contour variation were all the mechanical complications we discovered through the search of the included articles. The loss of contact points was the major problem with ISPCs, approximal contact point variation was 18% and the occlusion deviation had 17.3% of the mechanical complications rate. Meanwhile implant fracture 1.09%, screw fracture 1.2% and veneering fracture 1.81% were the least to appear in ISPCs (according to the selected articles). According to the search, biomechanical complications rate with standard-length implants (17.87%) is higher than with short-length implants (1.64%). We noted that the results could not be really precise due to lack of concrete information in some articles (Di Francesco et al, Clin oral invest) or it is not even mentioned as it's the case of Agustin-Panadero et al.

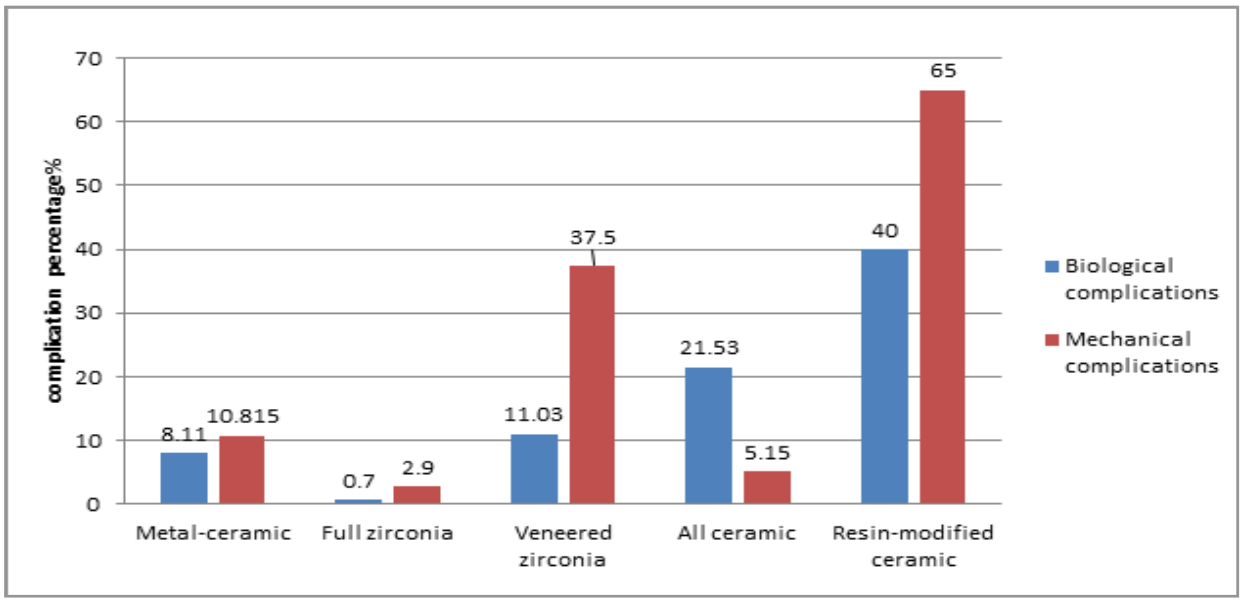

Figure 3: Bio-mechanical complications depending on the material type

Table III: Biological complications percentage according article's data

Article	periim-lantitis %	ossointe-gration Failure	aseptic loosen-ing %	Bone loss %	periim-plant mucosi-tits %	peri-odontitis %	plaque retention %	Infection %	Pain and swelling	perma-nent neuro-sensory distur-bance %	mean percent-age %
Wolfart, et al. (2)	11	-	-	100	16.05	-	12.46	-	-	-	34.88
Cheng, et al. (3)	-	0.70	-	-	-	-	-	-	-	-	0.70
Di Fran-cesco, et al. (5)	2.32	1.16	-	-	-	-	-	-	-	-	1.74
Cionca, et al. (7)	12.24	2.04	10.20	-	15.75	1.50	15.50	0	-	-	8.18
Nielsen, et al.	-	-	-	100	0.40			0.40	10	0.4	22.24
Clin oral Invest	0	0	0	0	0	0	0	0	0	0	0.00
Augustin panadero, et al.	0.1	0.5	-	-	32.5	-	-	-	-	-	11.03
Mean percent-age	6.42	1.1	10.20	100	16.18	1.5	13.98	0.2	10	0.4	11.25

Table IV : Mechanical complications and failure percentage according article's data

Article	Screw loosen-ing %	Screw fracture %	Veneer-ing chip-ping %	Ve-neering Frac-ture %	Loss of reten-tion %	Abute-ment fracture %	Implant fracture %	Crown fracture %	Occlu-sion de-viation %	Approx-imal contact varia-tion %	Approx-imal contour varia-tion %	Mean percent-age %
WOL-FART et al (2)	3	-	0	1.78	12.46	-	-	-	32	18	3.57	10.12
Cheng et al (3)	8.80	-	-	1.45	2.95	-	0	0	-	-	-	2.64

Di Francesco et al (5)	1.20	1.20		1.2	2.30	1.70	2.30	-	-	-	-	8.20
ClONCA et al (7)	-	-	-	-	12.24	12.24	2.04	-	-	-	-	17.50
Nieisen et al (8)	8.88	-	2.22	2.22	-	2.22	-	-	-	-	-	3.89
Clin Oral Invest (6)	-	-	3.30	1.80	-	-	0	0	2.60	-	-	1.54
Agustin Panadero et al (4)	-	-	5	-	22.50	-	-	15	-	-	-	37.50
Mean Complications percentage	5.47	-	2.68	-	10.49	-	-		17.30	18	3.57	11.63
Mean failure percentage	-	1.20	-	1.81	-	5.39	1.09	5	-	-	-	2.90

Table V: Bio-mechanical complications in different types of implants:

Article	Cement-retained percentage%		Screw-retained percentage%		Short implants (>=9mm) Complications percentage%	Standard length (>=9,>=13mm) Complications percentage%
Complications type	Biological	Mechanical	Biological	Mechanical		
WOLFART et al (2)	59.8	21.4	61.02	28.6	-****	1.9
Cheng et al (3)	2.77	8.7	0	63.7	0	0
Di Francesco et al (5)	1.74	1.2	1.74	2.3	1.15***	1.15***
ClONCA et al (7)	8.18***	12.24	-****	-****	2.04	16.32
Nieisen et al (8)	-*	-*	-*	-*	5	70
Clin Oral Invest (6)	0	-*	0	-*	0	-****
Agustin Panadero et al (4)	-*	22.50**	-****	-****	-****	-****
Mean percentage	14.5	13.2	20.92	31.53	1.64	17.87

*This information was not detailed in the article.
**The data was taken from table IV and V due to lack of information.
***In the study they did mention that four implants (2.3%) failed, two of which (3.5 × 11 mm) failed early after 2 and 4 months of loading, and 2 that were removed because of marginal bone loss with peri-implant inflammation at 41 (3.5 × 9 mm) and 52 (4 × 9 mm) months after loading ().
****The study's sample does not include that type of restoration (Table III), (Table IV).

Discussion

This systematic review assessed the biomechanical complications of implant supported posterior crowns by studying the different types of biomechanical complications and explaining their causes focused on the results of prospective clinical studies, controlled clinical studies, cohort studies and a retrospective study that would compare head-to-head biomechanical complications along with a randomized clinical trial. The interest of our systematic review is to study the biological and mechanical complications in implant-supported posterior single crowns in order to figure out the proper protocol in order to prevent any further failure as well as the patient's comfort.

As shown from the results of the search, the types of biological complications were: bone loss, osseointegration failure, peri-implantitis, peri-implant mucositis, periodontitis, aseptic loosening, plaque retention, infection, pain swelling and permanent neurosensory disturbance. We can also find Fistulas and suppuration [9]. As the search had shown a complication percentage of 11.25%. In this study it was noted that resin-modified ceramic had the highest percentage of complications (40%), this information could be reserved due to lack of details. Due to its susceptibility to erosion and lower strength, resin-modified ceramic was considered more like composite resin [4]. On the other hand full zirconia ISPCs had the least complications(0.7%) due to its biocompatibility In this study we noted that cemented

ISPCs had less complication percentage(13.2%) than screw-retained ISPCs(31.53%).In the study of WOLFART et al we noted a 6.9% excess of cement in the approximal sides of the restauration caused a 33.88% of the biological complication, the Jain et al study reinforced this theory , they claimed that excess of cement leaded to periimplantitis [10,11]. According to Quaranta et al crown to implant ratio caused peri-implant mucosal inflammation and increased probing depth Alqutaibi et al reported the poor marginal fit of ceramic crowns could perhaps lead to bacterial accumulation and subsequently chronic inflammation [12,13]. As shown in the Z.Zheng et al the biological width forms as a defensive mechanism against the bacteria, influences the remodeling of soft and hard tissue around implant,so every disruption of the biological width would leas to the appearing of peri-implant diseases (peri-implant mucositis, periimplantitis [14].

According to the conducted search, alveolar bone loss was the most frequent complication100%, even though it was reported only two studies, the rest did mention bone level variation. The study conducted byAlqutaibi et al had reported that the most common reported biological complication was suppuration [13]. WOLFART et al uncovered a causality relation between excess of cementation and marginal bone loss [11]. DELGADO-RUIZ et al had put in light the association of the functional mastication loads and parafunctional loads on the bone loss. The same study linked the percentage of bone loss to the bone quality, architecture, implant dimensions, geometry and material properties. Some articles suggested that crown to implant ratio is a reason for marginal bone loss as for Romanos et al poorly constructed implant systems may result in higher incidence of biological complications [15-17).

This systematic review showed a mechanical complications percentage that reached 11.63%, and a mechanical failure percentage of 2.9%. The search had led to identify the different types of mechanical complications: screw loosening, veneering chipping, loss of retention, occlusion deviation, approximal contact and contour variation. It had also identified types of mechanical failures such as: screw fracture, veneering fracture, abutment fracture, implant, fracture and crown fracture.

The search showed that the statistically highest complication was loss of retention as for the majority of searches agrees with this statement, except for two studies that considered chipping of the veneering ceramic was the most frequent complication [13-18]. In this study we noted a noticeable difference between cemented and screwretained mechanical complications percentage 13.2% and 31.53%, so failures in the screw-retained crowns were more frequent compared to cemented crowns According to the Jain et al study the excess of cement leads to loss of retention, according to literature fatigue, inadequate tightening torque, inadequate prosthesis fit, poorly machined components, vibrating micro-movement and excessive loading are a few to mention causes of ISPCs retention loss [11-15].

According to the current study, only 5.47% of ISPs had witnessed screw loosening and another 1.2% had had a fractured screw. Screw loosening in molars was seen frequent in the study of KATSAVOCHRISTOU and KOUMOULIS, it had also explained the cause of screw fracture as it had shown a fracture pattern in the body of the screw due to physical properties of the material, the design and dimension of the components and the applied torque level [19].

The thorough search conducted in this study revealed a 2.68% of veneering chipping and 1.81% for veneering fracture. Since veneered zirconia presented a high complication percentage (37.5%), the studies had shown that the veneering ceramic chipping was considered one of the most common problems for ceramic zirconia-based prosthesis and theoretically was caused by the adhesion interface due to debonding of the zirconia infrastructure and veneering ceramic [9].

PJETTURSON et al claimed that all-ceramic ISPCs supported by zirconia implants were prone to chipping, adding to this the failure due to core fracture was significantly higher for the monolithic-reinforced glass-ceramics [20]. The framework material plays an important role in preventing high chipping rates, also Humidity, chemical attacks like acidic food or drinks, and changing temperatures lead to accelerated aging of ceramics. With aging, the risk of fracture or chipping increases [21]. According to SPIZNAGEL et al. Titanium implant-supported all ceramic crowns demonstrated comparatively low chipping rate [18].

In this study we found that standard length implants had a significantly higher complications rate (17.87%) compared to short implants (1.64%) both situated in the posterior area of the arch. According to SOUZA et al, short implants tended to have higher crown-to implant ratio than standard implants which increased marginal bone loss Short implants tend to have higher crown-to-implant ratio than standard implants [22]. Laboratory studies show more stress of oblique forces on short implants when the crown-to-implant ratio approaches, this may interfere with fatigue of prosthetic abutments and also result in more MBL [22].

Limitations

Difference in settings (universities vs private dental clinics), implant loading protocols, experience, age and clinical experience of operators, periodontal factors, alveolar bone history made the drawing of definitive conclusions very difficult. However, it was encouraging that according to most authors, implant- supported posterior crown presented a moderated biomechanical complications rate. Unfortunately, the authors of all papers did not provide details and clear information about the percentages of biological and mechanical complications, the precise information's of implants and their materials and the incidence of bone loss and other types of biomechanical complication. According to the findings in this systematic review, a great heterogeneity of (control and study groups), no homogenous restauration material type groups and a short follow-up examination was observed.

Conclusion

Biomechanical complications can pose challenges to the long-term stability and function of implant-supported posterior crowns. The dynamic oral environment, coupled with occlusal forces and parafunctional habits, can contribute to complications such as abutment (5.39%) or screw fractures (1.2%), framework or porcelain fractures (1.81%), implant overload, and crestal bone loss (100%). Understanding these complications is essential for successful treatment outcomes. Proper treatment planning, meticulous occlusal analysis, material selection, and regular maintenance are crucial in minimizing the risk of bio-

mechanical complications. By keeping in mind these concerns, technicians can enhance the longevity and performance of implant-supported posterior crowns, improving patient satisfaction and oral health. Further research and advancements in implant design and materials will continue to contribute to reducing biomechanical complications and enhancing the success of implant dentistry [2-8].

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