Dental Research Journal

Systematic Review and Meta-analysis Article

Comparison of the outcomes and complications of three-unit porcelain-fused-to-metal tooth-implant-supported prostheses with implant-supported prostheses: A systematic review and meta-analysis

Amirhossein Fathi[1], Ramin Atash[2], Elmira Fardi[3], Mahsa Nili Ahmadabadi[4], Sara Hashemi[5]

[1]Dental Materials Research Center, Department of Prosthodontics, School of Dentistry, Isfahan University of Medical Sciences, Isfahan, Iran, [2]Department of Prosthodontics, School of Dentistry, Faculty of Medicine, University Libre de Bruxelles, Brussels, Belgium, [3]Dentist, Tehran, Iran, [4]Department of Esthetic and Restorative Dentistry, School of Dentistry, Isfahan University of Medical Sciences, Iran, [5]Graduate Student, Dental Students Research Committee, School of Dentistry, Isfahan University of Medical Sciences, Isfahan, Iran

Received: 05-Mar-2022
Revised: 21-Jul-2022
Accepted: 10-Aug-2022
Published: 18-Jan-2023

Address for correspondence:
Dr. Amirhossein Fathi, Department of Prosthodontic, Isfahan University of Medical Sciences, Hezar-Jerib Ave., Box: 81746 73461, Isfahan, Iran.
E-mail: amir_alty@yahoo.com

ABSTRACT

Background: The aim of the current study was to evaluate the outcomes and complications of three-unit porcelain-fused-to-metal tooth-implant-supported prostheses in comparison with implant-supported prostheses.

Materials and Methods: In this review article, the electronic databases, PubMed, Scopus, LILACS, Web of Science, EBSCO, LIVIVO, and Embase were searched over the past 20 years until December 2021. Risk ratio with 95% confidence interval (CI), fixed effect model, and Mantel–Haenszel method was calculated. The meta-analysis was performed with the statistical software Stata/MP v. 16.

Results: Two hundred and three studies were selected for reviewing the abstracts, from which the full texts of 16 studies were reviewed. Finally, five studies were selected. The risk ratio of prosthesis failure between the tooth-implant-supported prosthesis and the implant-supported prosthesis was RR (Risk Ratio)= 1.83 (0.79, 4.24), (P = 0.16) and for prosthesis complication, it was RR = 0.61 (0.35, 1.06), (P = 0.08). Risk ratio of implant failure between the mentioned groups was RR = 2.33 (0.84, 6.41), (P = 0.10), and for implant complications, this rate was 0.09 (RR, 0.09 95% CI − 1.30, 1.48; P = 0.90).

Conclusion: The meta-analysis of the present study showed that there was no significant difference between the two groups (three-unit porcelain-fused-to-metal tooth-implant-supported prosthesis and implant-supported prosthesis reconstruction) in terms of the total failure of implants and prostheses and the complication rate of implants and prostheses.

Key Words: Dental Prosthesis, meta-analysis, systematic review

INTRODUCTION

It is known that missing teeth, especially in the posterior area, is associated with temporomandibular symptoms.[1] Drift and tipping can cause secondary changes in occlusal contact and overall occlusal function.[2] For years, edentulous patients have been treated with a removable prosthesis or cantilever bridge.[3] Studies on dental implants have increased

Access this article online

Website: www.drj.ir
www.drjjournal.net
www.ncbi.nlm.nih.gov/pmc/journals/1480

How to cite this article: Fathi A, Atash R, Fardi E, Ahmadabadi MN, Hashemi S. Comparison of the outcomes and complications of three-unit porcelain-fused-to-metal tooth-implant-supported prostheses with implant-supported prostheses: A systematic review and meta-analysis. Dent Res J 2023;20:3.

dramatically from 1960 to 1980, while dental implants were used only in people with complete edentulousness. With time pass and increasing research, fixed partial dentures (FPDs) supported by free-standing implants were introduced for the treatment of semiedentulous patients.[4] In edentulous patients in the posterior molar region, dealing with limited bone mass should be considered; this is due to the presence of important anatomical structures (maxillary sinus or the inferior alveolar nerve), which is why the treatment plan must be designed accurately.[5] Linking the implant to the distal-end natural tooth not only reduces the number of implants required to gain sufficient support but also helps preventing the nerve canals or the maxillary sinus from danger, thereby simplifying the surgical procedure. In addition, this approach can help retain the prosthesis with the corresponding proprioceptive periodontal ligament and eliminate the requirement of cantilever bridges.[6] The three-unit bridge that combines a natural tooth and an implant provide extended treatment possibilities for partially edentulous patients. Many studies have examined three-unit porcelain-fused-to-metal tooth-implant-supported prosthesis designs.[7,8] Although some researchers revealed that when the FPD was connected to the three natural abutment teeth and an implant, the bone stress level is minimum,[9] some revealed the stress distribution in these restorations is significantly unequal, causing the maximum failure rate for the prosthesis.[10] However, the combination of natural teeth and implants in clinical practice is controversial. Therefore, the purpose of the current study was to evaluate the outcomes and complications of three-unit porcelain-fused-to-metal tooth-implant-supported prostheses and compare them with implant-supported prostheses.

MATERIALS AND METHODS

Search strategy

The present study is a systematic review and meta-analysis. Preferred Reporting Items for Systematic Reviews (PRISMA) was followed meticulously.[11] PICO strategy to answer the research question was formed as following: (it has to be mentioned that in the present study the word "complication" refers to when FPDs have been subjected to at least one technical modification (like reintegration, repair of veneer fracture or fracture of frame) and failure implies the situation that prosthesis or implant cannot be modified, and there is a necessity to exclude the whole part.)

P: Individuals with FPDs

I: Tooth-implant-supported FPDs

C: Implant-supported prostheses

O: Failure rate, complication rate

PRISMA protocol consists of five stages: systematic literature search, study selection, data evaluation, data extraction, and data classification. To achieve the overall aim of the study, in the first step, the studies published in the databases of PubMed, Scopus, Web of Science, and EBSCO until December 1, 2021, were reviewed. A software program (Endnote X7, Thomson, Reuters, New York, USA) was used to manage electronic titles.

Search structures were performed using mesh terms:

(((((“Mouth, Edentulous” [Mesh] OR “Jaw, Edentulous, Partially” [Mesh] OR “Jaw, Edentulous” [Mesh]) OR “Failure of Tooth Eruption, Primary” [Supplementary Concept]) AND “Dental Prosthesis, Implant-Supported” [Mesh]) OR (“Prosthesis Design” [Mesh] OR “Dental Prosthesis Design” [Mesh])) AND “Treatment Outcome” [Mesh]) AND “complications” [Subheading].

Selection criteria

Inclusion criteria

Randomized controlled trial studies, controlled clinical trials, prospective and retrospective cohort studies, and treatment using a combination of tooth-implant-supported prosthesis were included in the study.

Exclusion criteria

In vitro studies, case–control studies, case reports and reviews, single crown, and multiunit prostheses were excluded from the study.

Data extraction and analysis method

Data extracted from the studies included years, study design, number of patients, number of prostheses and implants, number of teeth, and prosthesis design. To extract the data, two-blinded and independent reviewers extracted the data from the abstract and full text of the studies. Before screening, kappa statistics were performed to confirm the level of agreement between the reviewers. Kappa values were higher than 0.80.

The ROBINS-I was a tool developed to assess the risk of bias in the results of nonrandomized studies

that compared the health effects of two or more interventions.[12]

Risk ratio with 95% confidence interval (CI), fixed effect model, and Mantel–Haenszel formula were calculated. Random effects were used to deal with potential heterogeneity and I^2 showed heterogeneity. I^2 values above 50% signified moderate-to-high heterogeneity. The meta-analysis was performed using the statistical software Stata/MP v. 16 (The fastest version of Stata, StataCorp, California, US).

RESULTS

A total of 218 articles were found in the initial search. After removing duplicates, entry criteria were applied to the titles of the remaining 203 articles, and an abstract of the remaining articles was reviewed. In this step, 187 articles were excluded from the study. Then, the full text of 16 articles was reviewed, and 11 articles were excluded due to the lack of access to the full text of the article and not being relevant to the title and purpose of the article. Eventually, five studies were selected [Figure 1].

Characteristics

Five studies (four prospective and one retrospective studies) have been included in the present article. The total number of teeth was 101, and one study[13] did not report the failure or complication rates of implant and only provided data about prostheses issues. The number of patients in total was 491 with 131/135 tooth-implant-supported prostheses/implants and 348/674 implant-supported prostheses/implants [Table 1].

Assessing risk of bias

According to the ROBINS-I tool, all studies presented a low risk of bias except for two studies which had a moderate risk of bias [Table 2]. The publication bias was also not statistically significant due to Egger's test.

Prosthesis failure rate

In tooth-implant-supported prosthesis and implant-supported prosthesis groups, the number of prosthesis failures was 7/124 (5.64%) and 15/263 (5.70%), respectively [Figure 2].

Risk ratio (95% CI) of prosthesis failure between tooth-implant-supported prosthesis and implant-supported prosthesis was RR = 1.83 (0.79, 4.24), (P = 0.428) with low heterogeneity (I^2 < 0%; P = 0.78) [Figure 2]. This result shows no statistically significant difference in prosthesis failure between the two groups

Implant failure rate

Risk ratio (95% CI) of implant failure between tooth-implant-supported prosthesis and implant-supported prosthesis was RR = 2.33 (0.84, 6.41), (P = 0.10) with low heterogeneity (I^2 < 0%;

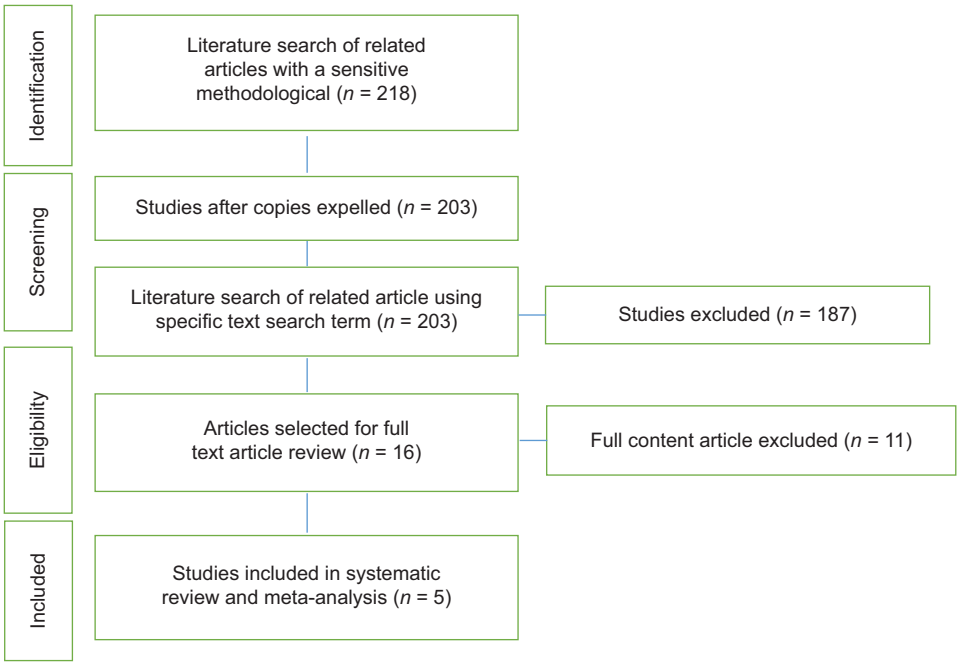

Figure 1: Flowchart of the literature search and selection criteria

Table 1: Summary of characteristics of included studies

Study (years)	Study design	Number of teeth	Number of patients	Number of prostheses/ implants	
				G1	G2
Mostafa *et al.*, 2015[14]	Prospective	10	20	10/10	10/20
Rammelsberg *et al.*, 2013[13]	Retrospective	NR	166	48/52	118/189
Akça and Cehreli 2008[15]	Prospective	34	29	34/34	15/30
Romeo *et al.*, 2004[10]	Prospective	31	250	13/13	179/379
Lindh *et al.*,2001[16]	Prospective	26	26	26/26	26/56

G1: Tooth-implant-supported prosthesis; G2: Implant-supported prosthesis. NR: Not reported

Table 2: Risk of bias assessment (risk of bias in nonrandomized studies of interventions)

Study	Preintervention		Intervention	Postintervention				Total score
	Bias due to confounding	Selection bias	Classification of interventions	Deviation from intended interventions	Bias due to missing data attrition	Bias in measurement of outcomes	Bias in selection of reported results	
Mostafa *et al.*, 2015[14]	+	+	+	+	+	+	+	7
Rammelsberg *et al.*, 2013[13]	?	+	+	+	+	+	+	6
Akça and Cehreli 2008[15]	+	+	+	+	+	+	+	6
Romeo *et al.*, 2004[10]	+	+	+	+	+	+	+	7
Lindh *et al.*, 2001[16]	+	+	+	+	+	?	+	6

+: Low; ?: Unclear; -: High

P = 0.93) [Figure 3]. In tooth-implant-supported prosthesis and implant-supported prosthesis groups, the number of implant failures was 4/90 (4.4%) and 13/417 (3.11%), respectively, although this difference was not statistically significant [Figure 3].

Prosthesis complication rate

In tooth-implant-supported prosthesis and implant-supported prosthesis groups, the numbers of prosthesis complications were 13/118 (11.01%) and 42/247 (17%), respectively [Figure 4]. Risk ratio (95%CI) of prosthesis complication between tooth-implant-supported prosthesis and implant-supported prosthesis was RR = 0.61 (0.35, 1.06), (P = 0.08) with low heterogeneity (I^2 < 0%; P = 0.79) [Figure 4]. However, this result shows no statistically significant difference in prosthesis complications between the two groups.

Implant complication rate

In tooth-implant-supported prosthesis and implant-supported prosthesis groups, the number of implant complications was 1/100 (1%) and 7/407 (1.71%), respectively [Figure 5].

Risk ratio of implant complication between tooth-implant-supported prosthesis and implant-supported prosthesis was RR = 1.10 (0.27, 4.41), (P = 0.90) with low heterogeneity (I^2 < 0%; P = 0.65) [Figure 5], As a result, there is no statistically significant difference in implant complications between the two groups.

DISCUSSION

One of the most challenging issues in linking a tooth to an implant is the mobility between the tooth and the implant (10-fold difference). Based on previous studies, when implanting, bending moment with a cantilever effect might be generated under loading force.[7] The aim of the current systematic review and meta-analysis study was to evaluate the outcomes and complications of three-unit porcelain-fused-to-metal

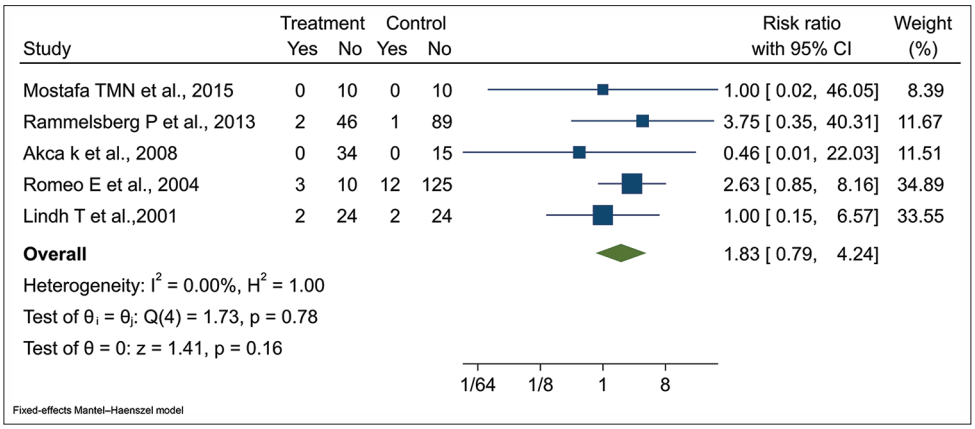

Figure 2: The forest plot showing prosthesis failure rate, RR (Treatment: tooth-implant-supported prosthesis. Control: implant-supported prosthesis) P-Egger's test = 0.428

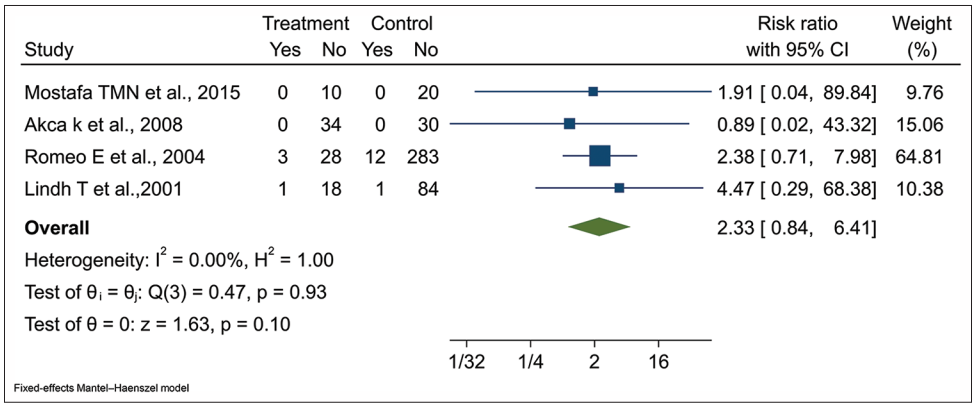

Figure 3: The forest plot showing implant failure rate, RR (Treatment: tooth-implant-supported prosthesis. Control: implant-supported prosthesis) P-Egger's test = 0.857

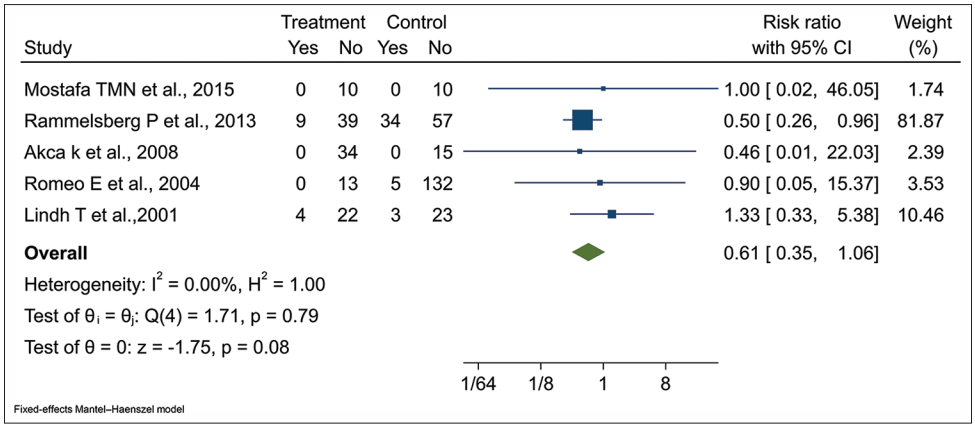

Figure 4: The forest plot showing prosthesis complication rate, RR (Treatment: tooth-implant-supported prosthesis. Control: implant-supported prosthesis) P-Egger's test = 0.520

tooth-implant-supported prostheses in comparison with implant-supported prostheses.

In the present study, no significant difference was observed between the group of three-unit porcelain-fused-to-metal tooth-implant-supported prosthesis and the group of implant-supported prosthesis reconstruction. Meta-analysis showed that both groups were almost similar in overall failure and complication rate of prosthesis and implant. However, a small difference was observed in overall prosthesis failure rate in the three-unit porcelain-fused-to-metal tooth-implant-supported prosthesis group (5.64%)

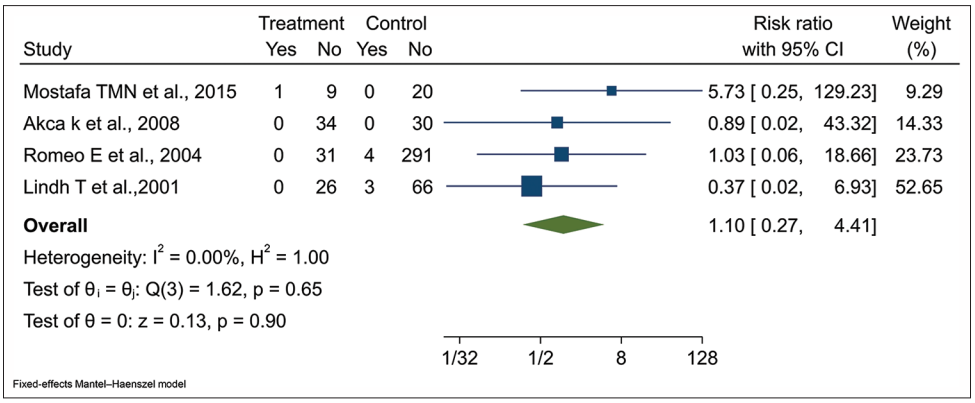

Figure 5: The forest plot showing implant complication rate, RR (Treatment: tooth-implant-supported prosthesis. Control: implant-supported prosthesis) P-Egger's Test = 0.900

and the implant-supported prosthesis group (5.70%). Moreover, the difference in overall implant failure rate and complication rate in the two groups was not statistically significant

A 4–5 year follow-up study revealed that FPD loss happened similarly in both tooth-implant-supported and implant-supported prosthetics but porcelain fractures occurred more on implants.[17] In total, clinical outcomes of tooth-implant-supported FPDs were acceptable in such follow-up duration. The findings of the present study are in consistent with mentioned study. Nickenig[18] reported that implant-supported FPDs technical complications are primarily related to the bridge design. As the use of rigid connectors reveals favorable outcomes in both tooth-implant-supported FPDs and implant-supported FPDs. According to Pratheep *et al*., when teeth and implants are linked, the FPD pontic should be as short as possible and should not be more than three units. They concluded that the bite force distribution and stress affect the result more than the connector.[8] It has been shown that repeated load fatigue is a reason for tooth-implant-supported prosthesis failure. To prevent overload, the number of implants should be increased and the bridge span distance should be reduced, so less load is placed on the tooth and more load is directed to the implant. This approach may optimize the distribution of stress in the system and reduce complications.[19] One of the limitations of the present study is the lack of randomized clinical trials in the meta-analysis. Further studies in this area, especially randomized clinical trial studies with long follow-up periods and higher sample sizes are required to provide sufficient evidence.

CONCLUSION

Current meta-analysis shows that there is no significant difference between the two groups (three-unit porcelain-fused-to-metal tooth-implant-supported prosthesis and implant-supported prosthesis reconstruction) in terms of the total failure of implants and prostheses and the complication of implants and prostheses. The findings show that in the implant-supported prosthesis reconstruction group, the rate of total prosthesis failure and the complication of implant and prosthesis complications are higher, whereas the rate of implant failure in the three-unit porcelain-fused-to-metal tooth-implant-supported prosthesis group was higher. Free-standing implants are used in patients who have lost their posterior teeth. To preserve natural teeth and reduce the complications of implant surgery, using a prosthetic treatment plan that can attach natural teeth to the implant can be another effective treatment option.

Financial support and sponsorship

Nil.

Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.

REFERENCES

1. Wang MQ, Xue F, He JJ, Chen JH, Chen CS, Raustia A. Missing posterior teeth and risk of temporomandibular disorders. J Dent Res 2009;88:942-5.
2. Singh DK, Jalaluddin M, Rajeev R. Trauma from occlusion: The overstrain of the supporting structures of the teeth. Indian J Dent Sci 2017;9:126.
3. Montero E, Molina A, Palombo D, Morón B, Pradíes G, Sanz-Sánchez I. Efficacy and risks of tooth-supported prostheses

in the treatment of partially edentulous patients with stage IV periodontitis. A systematic review and meta-analysis. Journal of Clinical Periodontology. 2022;49:182-207.
4. Sadowsky SJ, Landesman HM, Hansen WP. Implant Dentistry: Challenges in the Treatment of the Edentulous Patient. Evidence-based Implant Treatment Planning and Clinical Protocols. 2016;207.
5. Ahmad M, Jenny J, Downie M. Application of cone beam computed tomography in oral and maxillofacial surgery. Aust Dent J 2012;57 Suppl 1:82-94.
6. Huang YC, Ding SJ, Yan M, Huang TW. Clinical outcomes and complications of posterior three-unit porcelain-fused-to-metal restoration combined with tooth-implant-supported prosthesis: A meta-analysis. J Dent Sci 2022;17:184-93.
7. Naert IE, Duyck JA, Hosny MM, Quirynen M, Van Steenberghe D. Freestanding and tooth-implant connected prostheses in the treatment of partially edentulous patients: Part II: An up to 15-years radiographic evaluation. Clin Oral Implants Res 2001;12:245-51.
8. Pratheep KV, Abraham A, Annapoorni H, Vigneshwaran S. Comparative evaluation of stresses in tooth implant connected fixed partial denture by varying the implant design and position: A 3D finite element study. Indian J Dent Res 2013;24:439-45.
9. Dalkiz M, Zor M, Aykul H, Toparli M, Aksoy S. The three-dimensional finite element analysis of fixed bridge restoration supported by the combination of teeth and osseointegrated implants. Implant Dent 2002;11:293-300.
10. Romeo E, Lops D, Margutti E, Ghisolfi M, Chiapasco M, Vogel G. Long-term survival and success of oral implants in the treatment of full and partial arches: A 7-year prospective study with the ITI dental implant system. Int J Oral Maxillofac Implants 2004;19:247-59.
11. Vrabel M. Preferred reporting items for systematic reviews and meta-analyses. Oncol Nurs Forum 2015;42:552-4. 1.12. Sterne JA, Hernán MA, Reeves BC, Savović J, Berkman ND, Viswanathan M, *et al*.
12. Sterne JA, Hernán MA, Reeves BC, Savović J, Berkman ND, Viswanathan M, *et al*. ROBINS-I: A tool for assessing risk of bias in non-randomised studies of interventions. BMJ 2016;355:i4919.
13. Rammelsberg P, Schwarz S, Schroeder C, Bermejo JL, Gabbert O. Short-term complications of implant-supported and combined tooth-implant-supported fixed dental prostheses. Clin Oral Implants Res 2013;24:758-62.
14. Mostafa TM, El-Sheikh MM, Abd El-Fattah F. Implant-connected versus tooth-connected implant-supported partial dentures: 2-year clinical and radiographic comparative evaluation. Int J Periodontics Restorative Dent 2015;35:335-43.
15. Akça K, Cehreli MC. Two-year prospective follow-up of implant/tooth-supported versus freestanding implant-supported fixed partial dentures. Int J Periodontics Restorative Dent 2008;28:593-9.
16. Lindh T, Gunne J, Nyström E, Bäck T. Implant versus tooth-implant supported prostheses in the posterior maxilla: A 2-year report. Clin Oral Implants Res 2001;12:441-9.
17. Brägger U, Aeschlimann S, Bürgin W, Hämmerle CH, Lang NP. Biological and technical complications and failures with fixed partial dentures (FPD) on implants and teeth after four to five years of function. Clin Oral Implants Res 2001;12:26-34.
18. Nickenig HJ, Schäfer C, Spiekermann H. Survival and complication rates of combined tooth-implant-supported fixed partial dentures. Clin Oral Implants Res 2006;17:506-11.
19. Att W, Kurun S, Gerds T, Strub JR. Fracture resistance of single-tooth implant-supported all-ceramic restorations: An *in vitro* study. J Prosthet Dent 2006;95:111-6.