Evaluation of success rate of Zirconia based restorations: A systematic review

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Abstract
Background: Evaluation of the different causes listed in literature for the rate of success of Zirconia based restorations.
Material and Methods: With the help of PRISMA guidelines, this Systematic review was carried out. For a time span of 18 years that is from 2003 to 2020, articles were searched using three electronic data bases which are PubMed, Cochrane Library and Sciedirect. The selected 27 articles which included the in vivo as well as the in vitro studies presented the performance of zirconia-based prosthetic restorations. The studies also stated the commonest reason for failure which ultimately depicted the rate of success of the fixed dental prosthesis. Due to heterogeneity of gathered information, meta analysis could not be carried out.
Results: Failure of bond between veneer material and zirconia sub-structure could be related to the cause of fracture of veneering ceramic hypothetically.
Conclusions: Mechanical connection and building up of compressive strength due to thermal contraction at the time of cooling after sintering process is the reason for the bond developed amongst the two materials.

Key words: Zirconia based restorations, zirconia failure cause.

Introduction
Esthetics satisfying the contemporary consideration for attractiveness is treated with the help of prosthodontic treatment by traditionally restoring the lost function of speech, chewing and deglutition. Social burden and welfare of the profession maximizes the conditioned necessity of esthetics (1). The materials of choice for the cases in which esthetics is the key expectation are ‘Ceramics’ in recent times of which ‘yttria-stabilized tetragonal zirconia polycrystals’ (Y-TZP) is the most advanced core ceramic (1). This particular material enhanced high toughness and strength in multiple-unit FPDs. Even if zirconia-based ceramics being a prime material for fabricating FPDs, its high resistance to fracture could also endure high occlusal loads adding a major advantage. Nonetheless, cohesive fractures of the veneering ceramic is a ‘weak link’ of the restoration seen as the short-term clinical letdowns of zirconia-based restorations (1).
Material and Methods

- Review Question

Population – *In vivo* as well as *in vitro* studies performed with zirconia based restorations

Intervention – Studies with success rate of anterior and posterior zirconia based restorations as FPDs or single crowns.

Outcome – Overall success rate of the zirconia based restorations

-Literature search

From 2003 to 2020, articles were searched using three electronic data bases which are PubMed, Cochrane Library and Sciencedirect. Articles with full texts that contained the criteria for inclusion were attained. To include all relevant articles and for improving the electronic search, a final manual search was carried out amongst the selected articles to get cross references and citations.

PubMed provided 114 articles and Science direct provided 8 articles and citation search provided 17 articles after the electronic and manual search was done. So far, no systematic review has been published on the current topic. Total 80 articles were excluded and 59 articles were screened. These 59 articles were completely analyzed by the title and abstract leading to selection of only 27 relevant articles which served the criteria for inclusion considered for the systematic review.

Results

- Results of data extraction

By gathering all the data after excluding the duplicates, full text of these 27 articles was attained lead by thorough screening of the remaining 59 articles. Therefore, for this systematic review 27 articles was the final sample size.

- Results of included studies

No inference has yet touched regarding the attempt to substitute the metal in metal ceramic restorations having ceramics of greater resistance. Its discussion began at the end of the 20th century. In current situations, Zirconium oxide the foremost target of research and trials held clinically. Chemical along with dimensional stability, mechanical resistance, hardness, and modulus of elasticity of the similar demand that of stainless steel are the primary characteristics supporting its usage as a biomaterial.

Chipping of veneers often goes overlooked by the patient and is simply corrected by intraoral polishing or repair inferring that it is an esthetic defect of slight status. This is the reason which leads the rate of survival of zirconia-based fixed dental prostheses and metal ceramic restorations equivalent up to 97 to 99% over a period of 5 years.

The greatest numbers of problems due to the usage of zirconium oxide in prosthetic conducts occur with fixed partial prostheses or fixed bridges. Various studies clinically showed cohesive type of fracture of the veneer material as a major and utmost liability. However, there is a debate as to the rate of occurrence of this mechanical letdown because of variations in the variables evaluated in various studies and the success rate of the prostheses have been calculated. They have been summarized in Table 1.

| Author             | Type of Study | Follow up period | Number of restorations | Quantity and Type of Difficulty | Success rate |
|--------------------|---------------|------------------|------------------------|---------------------------------|--------------|
| Pospiech (2)       | Prospective   | 24 months follow up time | 38 (36 patients) Fixed partial prosthesis (FPP) | Chipping seen in 2 prostheses (5.2%) | 95.8%        |
| Bornemann (3)      | Prospective   | 18 months follow up time | 59 that is 46 patients in which FPP, 44 number of 3-piece and 15 number of 4-piece | Chipping seen in 2 prostheses (3.38%) | 96%         |
| Suárez (4)         | Prospective   | 18 months follow up time | 18 (16 patients) FPP (3-piece) | Endodontically treated post with root fracture 0 x chipping (0%) | 94.5%        |
| Vult von Steyern (5)| Prospective   | 24 months follow up time | 20 (18 patients) FPP (3-5-piece) | Chipping seen in 5 prostheses (15%) | 85%         |
| Raigrodski (6)     | Prospective   | 31 months follow up time | 20 (16 patients) FPP (3-piece) | Endodontic treatment of single tooth needed, chipping seen for 5 prostheses (25%) | 75%         |
| Sorensen (7)       | Prospective   | 36 months follow up time | 19 (19 patients) FPP (3-piece) | Chipping seen in single prosthesis (10.52%) | 90%         |
### Table 1 cont.: Success rate of prostheses calculated.

| Study          | Study Design | Follow-up Time | Prostheses Details | Fractures/Issues                                                                                   | Success Rate |
|----------------|--------------|----------------|--------------------|--------------------------------------------------------------------------------------------------|--------------|
| Edelhoff (8)   | Prospective  | 39 months      | 22 (18 patients) FPP (3- and 6-piece) | 1 adhesive fracture of veneer ceramic, chipping seen in single prosthesis (9.09%), endodontic treatment of single tooth needed | 90.5%        |
| Molin (9)      | Prospective  | 60 months      | 19 (18 patients) FPP (3-piece)     | 1 adhesive fracture 0 x chipping (0%)                                                              | 98%          |
| Crisp (10)     | Prospective  | 12 months      | 38 FPP (3- and 4-piece)            | Chipping seen in 2 prostheses (5.2%)                                                               | 95.8%        |
| Tinschert (11) | Prospective  | 37 months      | 65 (46 patients) FPP (3- and 10-piece) | Chipping seen in 4 prostheses (6.15%), endodontic treatment needed in 3 teeth, adhesive fracture seen in 2 prostheses | 94%          |
| Sailer (12)    | Prospective  | 40 months      | 36 FPP (3-5-piece)                | Endodontic treatment needed for single tooth, chipping seen in 9 prostheses (25%)                  | 75%          |
| Schmitt (13)   | Prospective  | 34 months      | 30 (30 patients) FPP (3-4-piece)   | Endodontic treatment needed for single tooth, chipping seen in 3 prostheses (10%)                  | 90%          |
| Schmitter (14) | Prospective  | 25 months      | 30 (27 patients) FPP (4-7-piece)   | FPP fracture of single tooth due to mechanical failure of connector (3.33%) 2 adhesive fractures Chipping of single prosthesis (3.33%) endodontic treatment needed for single tooth | 96%          |
| Wolfart (15)   | Prospective  | 48 months      | 24 (21 patients) FPP (3-piece)     | Secondary caries leading to single tooth loss, endodontic treatment needed for 2 teeth, 2 adhesive fractures chipping of 3 prostheses (12.5%) | 96%          |
| Eschbach (16)  | Prospective  | 54 months      | 65 (58 patients) FPP (3-piece)     | 1 complete fracture of FPP (1.53%) 1 tooth lost due to caries 2 adhesive fractures 4 x chipping (6.15%) | 94%          |
| Beuer (17)     | Prospective  | 35 months      | 18 FPP and 50 one-piece crowns (38 patients) | Fractures found only in FFPs: single tooth needed endodontic treatment and removal of FPP indicated, chipping seen in 5 prostheses (7.77%) endodontic treatment was needed for 2 teeth plus 2 cases of secondary caries | 88%          |
| Roediger (18)  | Prospective  | 50 months      | 99 prostheses that is 75 patients, FPP (3-4-piece) | Endodontic treatment needed for 1 tooth, secondary caries showed 3 cases, adhesive fractures 6 in number, chipping seen in 13 prostheses (13.13%) periodontal lesion lead to loss of single tooth | 94%          |
| Study                                      | Follow-Up Time | Success Rate |
|-------------------------------------------|----------------|--------------|
| Schmitt (19)                              | 62 months      | 92%          |
| Kern (20)                                 | 74 months      | 85%          |
| Peláez (21)                               | 36 months      | 90%          |
| Rinke (22)                                | 84 months      | 83.5%        |
| M. Barıs, Güncü et al. (23)               | 5 years        | 98%          |
| Shoko Miura et al. (24)                   | 12 years       | 67.2%        |
| Behnaz Ebadian et al. (25)                | No follow up   | 0%           |
| F. O. Abu-Izze et al. (26)                |                | 36.8%        |
| Rinke et al. (27)                         | 10 years       | 75%          |
| Shoko Miura et al. (28)                   | 3.5-year       | 92.8%        |
Discussion
The studies were divided into groups - In vivo and In vitro studies.
- Fixed prostheses with zirconia substructure – In vivo performance in studies
The authors Pospiech (follow-up of 24 months) (2), Beuer (follow up of 40 months) (17), Bornemann (18 months) (3), Crisp (follow up of 12 months) (10), Tinschert (follow up of 37 months) (11), Schmitter (25 months follow up) (14), and Eschbach (follow up of 54 months) (16) evaluated chipping as the main cause of failure of the fixed prosthesis in their respective studies.
Vult von Steyern in his study with 24 months of follow up period (5), Peláez with follow up period of 36 months (21), Edelhoff (39 months of follow up)(8), Schmitt (follow up period of 36 months) (13), Wolfart (48±7 months of follow up time) (15), Roediger (50 months follow up)(18), Kern (follow up period of 74 months) (20), and Sorensen (follow up period of 36 months) (7) inferred an occurrence of chipping that ranges between 9-15% with the success rate of 91% to 85% in posterior fixed partial prostheses.
Finally, diversity in the studies carried out by Raigrodski (with 31 months follow-up) (6), Sailer (40.3±2.8 months of follow up period) (12), Beuer (with 35±14 months follow up time ) (17), Schmitt (62 months follow up) (19) and Rinke (follow up period of 84 months) (27) say that frequency of chipping of veneer material on posterior fixed partial prostheses is in the range of 19-28% with rate of success ranging from 72-81%. Few authors – Molin (with 60-month follow-up)(9) and Suárez (follow up period of 18 months)(4) did not spot any mechanical problems amongst the restorations considered (Table 1-1 cont.-1)
- Fixed prostheses with zirconia substructure – In vitro performance studies
Concerning the mechanical performance of fixed prosthetic restorations, resisting the force of chewing deprived of getting fractured is the vital need. The first molar is exposed to 60-200N of mastication force. Forces generated Y-TZP posterior fixed partial dentures are higher than anterior maxilla and mandible. The rate of success was significantly predisposed by site, with crowns seated in the molar area displaying higher biological and technical difficulties than anterior crowns. Fractures of ceramic material were also knowingly influenced by site, with molar crowns showing more risk than anterior crowns.
The most recurring type of fracture was cohesive fracture which comprises of 88.8% (31).

Summary
The rate of success was significantly predisposed by site, with crowns seated in the molar area displaying higher biological and technical difficulties than anterior crowns. Fractures of ceramic material were also knowingly influenced by site, with molar crowns showing more risk for these fractures than anterior crowns. In vitro full-coverage restorations studies have seen a greater occurrence of cohesive type of fracture for zirconia restorations. The higher incidence of chipping is explained in a study by Martin Rosentritt (2009) that assayed zirconia restoration fracture resistance, finding that all samples suffered cohesive fractures due to inadequate performance of the veneer material (32).

Conclusions
The relationship between chipping phenomenon and risk factors occurring clinically, chiefly occlusal aspects, ought to be taken into consideration in upcoming prospective studies. Specific attention should be given by dental practitioners to clinical constraints when performing zirconia based restorations till an answer is found to enhance the mechanical resistance of the materials.

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There are no conflicts of interest.