Risk factors associated with tooth sensitivity in fixed dental prosthesis treatment: a literature review

Pablo Atria[1], Camila Sampaio[2], Daniela Rosas[3], Christian Córdova[4] , Eduardo Fernández[5] Gilbert Jorquera[6].

1 Universidad de Los Andes, Chile. 0000-0001-6298-9756

2 Universidad de Los Andes, Chile. 0000-0002-2517-7684

3 Universidad de Los Andes, Chile. 0000-0003-2250-0623

4 Universidad de Los Andes, Chile. 0000-0001-5024-7202

5 School of Dentistry, Universidad de Chile and Instituto de Ciencias Biomédicas, Universidad Autónoma de Chile, Chile. 0000-0002-2616-1510

6 Universidad de Los Andes, Chile. 0000-0001-9458-7890

Abstract

Vital teeth treated with fixed dental prosthesis undergo a pulpal inflammatory process during their preparation. This inflammatory response can be transient or perpetuate itself and become pulpal damage. As a result, postoperative sensitivity may appear in some patients during treatment and this could be related to certain risk factors. The objective of this work is to describe the risk factors related to postoperative thermal, chemical or mechanical sensitivity in treatments with fixed dental prosthesis.

Method: Different databases were used to search for studies that included the following keywords: dental sensitivity, dental hypersensitivity, pulp response, crown, fixed prosthesis, postoperative, postcementation, tooth preparation. All the studies found were analyzed according to the level of evidence, the quality of the report and the ethical implications.

Results: A total of 43 articles were selected. There were 10 clinical studies, 7 literature reviews and 26 in vitro studies. The level of evidence, the quality of the report and the ethical considerations were rated as acceptable.

Conclusions: The existing evidence describes some risk factors related to the postoperative sensitivity in three stages of the process of making a fixed dental prosthesis. However, it is not conclusive regarding its mechanism of origin or prevention, which is why we suggest conducting further randomized clinical studies.

Introduction

During preparation to receive fixed dental prostheses, vital teeth undergo a pulpal inflammatory process modulated by the actions taken by clinicians to prevent it.

This inflammatory response can be transient or perpetuate itself and become pulpal damage. Dental pulp registers any painful stimuli, regardless of its nature [1-2]. Maxillary and mandibular nerves are responsible for this nociception [2]. Although the way pain is transmitted through the dentin is unknown, the hydrodynamic theory, described by

Brännström in the eighties, is the most accepted one [2]. Tooth preparation for fixed dental prostheses is associated with stimuli that pose a risk of pulpal inflammation and tooth sensitivity caused by the necessary grinding. In general, these are short-term irritants, which trigger an acute inflammatory response [1]. This dentinal sensitivity is mainly associated with reversible pulpitis.

Pulpal damage is cumulative, therefore, every time it is under a dangerous stimulus, its repair capacity diminishes. It has also been found that in 2% to 25% of fixed prosthetic treatments there could be pulpal necrosis [5-6]. The information available in the literature varies, since an inflammatory state and postoperative sensitivity can be induced by multiple factors. The purpose of this literature review is to guide clinicians on the different factors associated with tooth sensitivity after treatment with a fixed dental prosthesis.

Method

Multiple databases were used in the search: Pubmed, Cochrane, BEIC, EBSCO and Google Scholar. The words used were: dental sensitivity, dental hypersensitivity, pulp response, crown, fixed prosthesis, postoperative, postcementation, tooth preparation, as well as Boolean terms *AND*, *NOT* and *OR.* Full-text articles of systematic reviews, narrative reviews, clinical studies and in vitro studies were included in the search without language restriction. Animal studies and articles without full-text article were excluded. The information obtained was organized in a Microsoft Excel table, specifying the year, study classification, the n number, the intervention, the results and the significance. Additionally, we conducted a critical analysis of each of the articles included and assigned a level of evidence and grade of recommendation according to the Oxford Center for Evidence-based Medicine. Each study was evaluated using the CONSORT checklist [7] for

clinical trials and the CRIS checklist for in vitro studies [8]. A score of 1 point was given for each item, with the maximum score possible being 25 points in the CONSORT checklist and 6 points in the CRIS checklist. Afterwards, each article was classified according to Tables 1 and 2.

Excellent	25 points
Good	18 – 24.5 points
Fair	9 -17.5 points
Poor	Less than 8.5 points

Table 1. Score classification according to the comparison table (CONSORT)

Excellent	6 points
Good	4 – 5 points
Fair	2 – 3 points
Poor	0 – 1 points

Table 2. Score classification according to the comparison table (CRIS)

Finally, we conducted an ethical evaluation based on whether an informed consent exists and was authorized by an ethics committee.

Results

We analyzed 43 articles which matched the inclusion criteria (7 reviews, 9 prospective clinical studies, 1 retrospective clinical study and 26 in vitro studies). All the articles selected were published between 1965 and 2015; 42 were written in English and 1 in Spanish; 9 were for prospective clinical trials, 1 for a retrospective clinical trial, 7 literature

reviews and 26 for in vitro studies. According to the level of evidence and the grade of recommendation of the clinical trials, 90% (9) had a 2b level of evidence according to the Oxford Centre for Evidence-based Medicine, with a B grade of recommendation. Only 10% (1) were in the 1b level and had an A grade of recommendation. An analysis of the quality of the clinical trials (using the CONSORT checklist) showed that 40% (4) of them were "good", 40% (4) were "fair" and 20% (2) were "poor". As for the quality of reporting in in vitro studies (CRIS checklist) [8], in 92% (24) it was "fair" and in 8% (2) it was "poor". None of the articles for clinical trials and in vitro studies analyzed were classified as "excellent". Regarding the ethical considerations of the clinical trials, only 15% (4) mentioned having received the approval of the Ethics Committee and 50% (13) mentioned the use of an informed consent.

Discussion

There is little evidence about the factors associated with postoperative sensitivity in the treatment with fixed dental prostheses. Most of the studies focus on pulp-dentin reactions and the inflammation which can be generated after the treatment, rather than on postoperative sensitivity. In addition, it seems reasonable to think that fixed prosthetic procedures induce more severe pulp reactions than other dental procedures given the increased number of exposed dentinal tubules [9]. Rosenstiel & Rashid applied a questionnaire to dentists about the prevalence, causes, and prevention of postcementation sensitivity. Most dentists believe that the prevalence of postcementation sensitivity is less than real prevalence, which is estimated at 10%. Irrigation with water spray was considered "very important" by 64.5% of respondents. Overheating and dentin desiccation were considered as the "most important" factor of all the factors considered by 18.6% of the dentists [10].

To organize the information, we analyze the postoperative sensitivity during the three stages of preparation for a fixed dental prosthesis.

1. Postoperative sensitivity associated with the biomechanical preparation

The consensus is that excess heat causes pulpal irritation, due to the motor's excessive speed, the shape and diameter of the bur, the amount and temperature of the coolant. Experts agree that using plenty of water is a simple and effective way of protecting the pulp [11]. Different water flows and temperatures have proven to be effective: 50 mL/min a 30ºC - 32ºC, (12) 50 mL/min at 29.8ºC - 33.7ºC [13], 40 mL/min at room temperature [14], 40 mL/min at 24ºC - 2ºC [11], 25 mL/min at room temperature [15]. Öztürk focused on the importance of reducing the high-speed air pressure and load for reducing heat generation [11]. There is disagreement over the thickness of the burs and their relation to heat generation. Ercoli et al. [14] and Galindo et al. [15] found no clinically important differences between burs; whereas Ottl and Lauer found that ultracoarse burs were associated with a greater increase in temperature, compared to finer burs [12]. From a histological perspective, the observation of odontoblast nuclei and erythrocytes inside dentinal tubules after dental preparation, which could be associated with the sensation of pain, can be explained by the hydrodynamic theory of dentinal pain proposed by Brännström [9]. It is widely known that if the remaining dentin is thick, the intrapulpal temperature rise will be lower [11-12]; there is no consensus on the minimum dentinal thickness necessary for protecting pulp tissue [16], but the minimum thickness necessary for pulp protection is 0.5 mm [17]. Although dentinal thickness plays an important role in protecting the pulp, it loses clinical relevance because there is no reliable way of measuring it in vivo. This shows the relevance of preserving the dental structure in a fixed

prosthesis preparation: a dentin layer measuring 1.5 mm or more can protect pulp tissue [18].

As mentioned above, dentinal tubules need to be exposed to cause tooth sensitivity [18-19]. It has been found that the deeper the preparation and the larger the surface area exposed, the higher the permeability of the dentin [18,20]. Multiple techniques for preventing the occurrence of postoperative sensitivity have been described. One of these techniques is the so-called "immediate dentin sealing" (IDS) [21], consisting in the immediate application and photo-polymerization of the adhesive system on the dentin, before the impression technique. This obliterates the openings of the dentinal tubules, thus stopping the bacterial invasion and the flow of dentin, which causes pain. According to the literature, this technique prevents postoperative sensitivity, increases adhesion strength and also reduces gaps and bacterial invasion.

In the in vitro quality evaluation of the studies, most were classified as "fair" according to the CRIS checklist, except for the articles by Davis et al. [22] and Lauer et al. [13], which were considered "poor". In addition, both of the clinical trials included in this section Langeland and Langeland [9], and Vitalariu and Caruntu [23] had a 2b level of evidence, but the quality of reporting was classified as "poor" according to the CONSORT checklist.

2. Postoperative sensitivity associated with the provisionalization stage

The most relevant factor mentioned in the literature regarding postoperative sensitivity in connection with provisionalization is the increase in temperature transferred into the pulp chamber. Several studies have shown that temperature increases are associated with

polymethylmethacrylate (PMMA), polyethylmethacrylate (PEMA), polyvinyl methacrylate (PVMA) and, finally, the Bis-acryl resin [24-25]. The thermal change produced by the latter has proven to be lower, and the self-curing set is associated with lower increases in temperature than the dual-curing group [26].

As mentioned before, the temperature rise inside the pulp chamber is not only connected to the material used, but also to the matrix chosen to hold such material [25,27,32-34].

The studies conducted by Molding and Teplitsky, and Michalakis et al. found that the smaller increase in temperature was directly related to the adjustment of the preformed crown [27,30]. Other studies indicate that the temperature is directly connected to the volume of material [27,35-36].

Based on different studies, we recommend selecting the provisionalization material and its matrix taking into account the exothermic reaction. Thus, the alginate matrix with bis-acryl resin should be the first choice, and PMMA with a silicone or thermoplastic matrix should be the last [25,27,32-33].

Moulding & Loney recommend different cooling techniques during provisionalization, without any significant difference between them: removing the restoration during polymerization (removal), using a spray of water/air while restorations remain in place (in situ) or removing the provisional restoration and cooling the preparation using an air/water spray, and putting the provisional back (on/off). It is important to be careful not to deform the provisional during the on/off and removal techniques [27].

3. Postoperative sensitivity associated with cementation

Among the elements analyzed, postoperative sensitivity associated with cementation is the one with the best studies in terms of quality, with most of them being clinical trials with a 2b level of evidence. Of those, 50% (3) were classified as "good" and 50% (3) as "fair"

according to the CONSORT checklist. Only the studies conducted by Shetty et al. [37-38] and Hassan et al. [38] meet the Ethics Committee approval and informed consent requirements. All in vitro studies, which lack external validity, are classified as "fair" according to the CRIS checklist (5). Johnson et al. [5] found that zinc phosphate causes more postoperative sensitivity to cold stimuli than conventional glass ionomers, but no difference was found after three months. Bebermayer & Berg [39] also analyzed postoperative sensitivity in relation to zinc phosphate and glass ionomers, and found no difference between them. This may be because the evaluation method used is a survey, instead of clinical evaluations, Kern et al. [40]. No differences were found between glass ionomers and zinc phosphate. This may be due to the fact that Kern et al. applied calcium hydroxide before cementation. Saad et al. [41] compared postcementation sensitivity with etch-and-rinse cements versus self-etching cements. After 12 weeks, they found that self-etching cements were associated with lower sensitivity. Patients treated with self-adhesive cements reported no sensitivity after 2 to 6 weeks, however, patients who underwent procedures with etch-and-rinse cements reported sensitivity even after 12 weeks. Blatz et al. [42] compared postcementation sensitivity with the self-adhesive resin cement and the resin-modified glass ionomer cement. They concluded that the self-adhesive cement is associated with a lower sensitivity compared to glass ionomers.

As for the mechanism that may cause postcementation sensitivity, acid etching has been noted as one of the main factors due to the removal of the smear layer, which allows for bacteria to flow inside dentinal tubules. The discrepancies between demineralized dentin and resin infiltration can also be a triggering mechanism, since they leave collagen exposed, which is associated with postoperative sensitivity. This is why self-etching cements are recommended, thus avoiding the removal of the smear layer [42]. pH values have also been linked to postcementation sensitivity. Glass ionomers and zinc phosphate have lower pH values than glass ionomers and resin cements [38-39,43]. According to Lam &

Wilson, who reported a greater transmission of pressure into the pulp chamber after the smear layer was removed, removing the smear layer can have a significant effect [43]. Immediate dentin sealing (IDS) is described as a barrier created by using adhesives after the smear layer is removed [21].

Conclusion

There is little evidence about the risk factors associated with postoperative sensitivity in the treatment based on fixed dental prostheses. Because of the lack of external validity, it is difficult to correlate in vitro studies with the clinical practice. Based on this review we can conclude that there seems to be a relation between any stimulus which can produce a movement of fluid inside the pulp and the occurrence of postoperative sensitivity. Nevertheless, the literature is not conclusive regarding its mechanism of origin or prevention, which is why we suggest conducting further randomized clinical studies.

References

1. Yu C & Abbott P An overview of the dental pulp: its functions and responses to injury. Aus Dent J. 2007; 52 (s1): s4-16.

2. Chung G, Jung S, Oh S. Cellular and molecular mechanisms of dental nociception. J Dent Res. 2013; 92 (11): 948-955.

3. Brännström M The hydrodynamic theory of dentinal pain: sensation in preparations, caries, and the dentinal crack syndrome. J of End. 1986;12 (10): 453-457.

4. Hargreaves KM, Cohen S, Berman LH. Vías de la pulpa.10th ed. Barcelona: Elsevier; 2011. 1004 p.

5.   Johnson GH, Powell L, De Rouen T. Evaluation and control of post-cementation pulpal sensitivity: zinc phosphate and glass ionomer luting cements. JADA. 1993;124 (11):38-46.

6.   Lockard MW. A retrospective study of pulpal response in vital adult teeth prepared for complete coverage restorations at ultrahigh speed using only air coolant. J of Prost Dent. 2002; 88 (5): 473-478.

7.   Sarkis-Onofre R, Cenci MS, Demarco FF, Lynch CD, Fleming PS, Pereira-Cenci T. Moher D. Use of guidelines to improve the quality and transparency of reporting oral health research. J Dent. 2015; 43 (4): 397-404.

8.   Faggion CM. Guidelines for reporting pre-clinical in vitro studies on dental materials. J of Evid Prac. 2012; 12 (4): 182-189.

9.   Langeland K, Langeland LK. Pulp reactions to crown preparation, impression, temporary crown fixation, and permanent cementation. J of Pros Dent. 1965; 15 (1): 129-143.

10.   Rosenstiel SF, Rashid RG. Postcementation hypersensitivity: scientific data versus dentists' perceptions. J of Prost. 2003; 12 (2): 73-81.

11.   Öztürk B, Üşümez A, Öztürk AN & Ozer F. In vitro assessment of temperature change in the pulp chamber during cavity preparation. J of Prost Dent. 2004; 91 (5): 436-440.

12.   Ottl P, Lauer H-C. Temperature response in the pulpal chamber during ultrahigh-speed tooth preparation with diamond burs of different grit. J of Prost Dent. 1998; 80 (1): 12-19.

13.   Lauer H-C, Kraft E, Rothlauf W, Zwingers T. Effects of the temperature of cooling water during high-speed and ultrahigh-speed tooth preparation. J of Prost Dent. 1990; 63 (4): 407-414.

14. Ercoli C, Rotella M, Funkenbusch PD, Russell S, Feng C. In vitro comparison of the cutting efficiency and temperature production of 10 different rotary cutting instruments. Part I: Turbine. J of Prost Dent. 2009; 101 (4): 248-261.

15. Galindo DF, Ercoli C, Funkenbusch PD, Greene TD, Moss ME, Lee HJ, Ben-Hanan U, Graser GN, Barzilay I. Tooth preparation: a study on the effect of different variables and a comparison between conventional and channeled diamond burs. J of Prost. 2004; 13 (1): 3-16.

16. Murray P, Smith A, Garcia-Godoy F, Lumley P. Comparison of operative procedure variables on pulpal viability in an ex vivo model. Int End J. 2008; 41 (5):389-400.

17. Murray PE, Smith A, Windsor L, Mjör I. Remaining dentine thickness and human pulp responses. Int End J. 2003; 36 (1): 33-43.

18. Richardson D, Tao L, Pashley DH. Dentin permeability: effects of crown preparation. J of Prost Dent. 1991; 4 (3): 219-25

19. Yadav K, Sofat A, Gambhir RS, Galhotra V. Dentin hypersensitivity following tooth preparation: A clinical study in the spectrum of gender. J Nat Sci. 2014; 5 (1): 21-4.

20. Outhwaite W, Livingston M, Pashley DH. Effects of changes in surface area, thickness, temperature and post-extraction time on human dentine permeability. Arc of Or Biol. 1976; 21 (10): 599-603.

21. Abu-Nawareg MM, Zidan AZ, Zhou J, Agee K, Chiba A, Tagami J, Pashley DH. Adhesive sealing of dentin surfaces in vitro: A review. Am J Dent. 2015; 6: 321-332

22. Davis GR, Tayeb RA, Seymour KG, Cherukara GP. Quantification of residual dentine thickness following crown preparation. J of Dent. 2012; 40 (7): 571-576.

23. Viţalariu A, Căruntu I-D, Bolintineanu S. Morphological changes in dental pulp after the teeth preparation procedure. Rom J Morphol Embryol. 2005; 46 (2): 131-136.

24. Driscoll CF, Woolsey G, Ferguson WM. Comparison of exothermic release during polymerization of four materials used to fabricate interim restorations. J of Prost Dent. 1991; 65 (4): 504-506.

25. Chadda AS, Verma P, Nagpal A, Samra RK, Verma R & Katna V. Evaluation Of Temperature Changes In Pulp Chamber During Direct Temporization Using Different Combinations Of Provisional Crown & Impression Materials-An In Vitro Study. Ind. J of Dent Sci. 2012; 4 (5): 23-27.

26. Lieu C, Nguyen T-M, Payant L. In vitro comparison of peak polymerization temperatures of 5 provisional restoration resins. J-Can Dent Ass. 2001; 67 (1): 36-39.

27. Moulding M, Teplitsky P. Intrapulpal temperature during direct fabrication of provisional restorations. J of Prost Dent. 1990; 3 (3): 299-304.

28. Altintas SH, Yondem I, Tak O, Usumez A. Temperature rise during polymerization of three different provisional materials. Clin oral inv. 2008; 12 (3): 283-286.

29. Xie C, Wang Z-y, He H-m, Han Y. In vitro pulp chamber temperature rise during fabrication of provisional restorations on different types of teeth. Int Chin J Dent. 2007; 7 69-74.

30. Michalakis K, Pissiotis A, Hirayama H, Kang K & Kafantaris N. Comparison of temperature increase in the pulp chamber during the polymerization of materials used for the direct fabrication of provisional restorations. J of Prost Dent. 2006; 96 (6): 418-423.

31. Kim S-h, Watts DC. Exotherm behavior of the polymer-based provisional crown and fixed partial denture materials. Dent Mat. 2004; 20 (4):383-387.

32. Tjan AH, Grant BE, Godfrey MF. Temperature rise in the pulp chamber during fabrication of provisional crowns. J of Prost Dent. 1989; 62 (6): 622-626.

33. Manak E, Arora A. A Comparative evaluation of temperature changes in the pulpal chamber during direct fabrication of provisional restorations: an in vitro study. J of Ind Prosth Soc. 2011;11 (3):149-155.

34. Chiodera G, Gastaldi G, Millar BJ. Temperature change in pulp cavity in vitro during the polymerization of provisional resins. Dent Mat. 2009; 25 (3): 321-325.

35. Tapia Silva R, Valenzuela Aránguiz V, Zamorano Pino X, Baena Águila R. Cuantificación de la generación térmica en acrílicos de autopolimerización. Avances en Odont. 2010; 26 (2):91-96.

36. Seelbach P, Finger WJ, Ferger P, Balkenhol M. Temperature rise on dentin caused by temporary crown and fixed partial denture materials: influencing factors. J of Dent. 2010; 38 (12): 964-973.

37. Shetty RM, Bhat S, Mehta D, Srivatsa G, Shetty YB. Comparative analysis of postcementation hypersensitivity with glass ionomer cement and a resin cement: an in vivo study. J Contemp Dent Pract. 2012; 13 (3): 327-331.

38. Hassan SH, Azad AA, Niaz O, Amjad M, Akram J, Riaz W. Post cementation sensitivity in vital abutments of metal-ceramic fixed partial dentures. Pak Or & Dent J. 2011;31 (1):1009-13.

39. Bebermeyer RD, Berg JH Comparison of patient-perceived postcementation sensitivity with glass-ionomer and zinc phosphate cements. Quint Int.1994;25 (3):209-14.

40. Kern M, Kleimeier B, Schaller H-G, Strub JR. Clinical comparison of postoperative sensitivity for a glass ionomer and a zinc phosphate luting cement. J of Prost Dent. 1996;75 (2):159-162.

41. Saad DE-D, Atta O, El-Mowafy O. The postoperative sensitivity of fixed partial dentures cemented with self-adhesive resin cements: a clinical study. JADA. 2010;141 (12):1459-1466.

42. Blatz MB, Mante FK, Saleh N, Atlas AM, Mannan S, Ozer F. Postoperative tooth sensitivity with a new self-adhesive resin cement—a randomized clinical trial. Clin Or Inves. 2013;17 (3):793-798.

43. Lam CW, Wilson P. The effect of dentine surface treatment on pulpward pressure transmission during crown cementation: a laboratory study. Int Dent J.1998;48 (3):196-202.

Eduardo Fernandez: edofdez@yahoo.com