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ORIGINAL ARTICLE

Pulp vitality during ultrasonic tooth preparation. Part 2

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ABSTRACT

BACKGROUND: Ultrasonic devices have a lot of dental application specially in hygiene and surgery. However there are some disadvantages like cut slowness and heat production. Prosthodontics application is less investigated. In particular the heat production could be an important factor for the clinician. In fact more than 5.5 °C temperature increasing could determine pulp necrosis during tooth preparation. The aim of this study is to investigate the increasing of temperature during finishing line repositioning and polishing phases using ultrasounds inserts and to verify if it remains within the limit of 5.5 °C.

METHODS: A sample of 32 human molars (extracted for periodontal reasons) was selected. The teeth were endodontically treated and prepared with burs in order to obtain a prosthetic round chamfer preparation, leaving the apical portion pervious for inserting the thermocouple probe. Then, they were inserted in plaster cubes up to the cement-enamel junction. A wall has been selected for each tooth for margin repositioning and finishing and prepared with the piezoelectric instrument (Multipiezo Touch with TipHolder DB2, Mectron, Carasco, Genoa, Italy). A mechanical arm was used to standardize the operator-dependent parameters. These parameters were: the pressure exerted on the dental wall, the cutting length and the time required for margin repositioning and finishing. The test phase consisted in a first stage of margin repositioning using an regular ultrasound tip with a diamond grain of 120 micron (DB120, Mectron, Carasco, Italy) (group 1), followed by a second finishing step conducted by a extra fine ultrasound tip with a diamond grain of 60 micron (DB60, Mectron, Carasco, Italy) (group 2). Each test lasted 60 seconds: this was the time that the mechanical arm needed to accomplish 32 rides. During these stages the intrapulpal temperature has been recorded thanks to a thermocouple. The obtained temperature data were analyzed by Kruskal-Wallis test and Mann-Withney *post-hoc* test, without Bonferroni correction ($P<0.001$).

RESULTS: The average pulpal temperature increase was 4.65 °C with a standard deviation of 0.99 °C for the DB 120 ultrasonic tip and 5.40 °C with a standard deviation of 0.84 °C for the DB 60 ultrasonic tip. However, neither of the instruments reach the medium critical level of 5.5°C reported in the literature, there are some single values who exceed it. There is statistically significant difference using tips with different granulometries within the two groups (P value =0.013).

CONCLUSIONS: Ultrasonic tools are very performing to achieve results in repositioning and polishing of prepared tooth. The *in-vitro* analysis show that the pulp temperature increasing remains within the safe limits literature shows. It is important underline the polishing phase is the most critical and the clinicians have to pay attention to irrigation and pression to avoid pulp damages. Additional clinical studies have to be performed to confirm these results.

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KEY WORDS: Pharmaceutical preparations, dental; Dental pulp; Dental pulp diseases.

Ultrasonic instruments are very important devices in dental practice. They could be used in different fields, usually in surgery[1-4] and dental hygiene[5] where the positive effect is amplified by using bicarbonate and glycine powder.[6] In recent years some researcher developed prosthodontic applications: ultrasonic tips can be very useful in prosthetic dentistry to perform the finishing line

repositioning and the refinement of a prepared tooth.[7-10]

Within last thirty years researchers involved in developing ultrasonic appliances investigated on biological effects upon tissues.[11] The most important field of research were bone surgery and implant dentistry.[12-14]

Cutting precision and efficiency, atraumatic interaction with soft tissues, including nerves are advantages of piezoelectric surgery. Moreover an implant made with an ultrasonic equipment[12-15] gives an improvement of osseointegration whilst recognizing the increasingly positive effect of many others factors as implant's surface s[16-18] and insertion torque.[19]

Given that mainly a prosthetic procedure should not be traumatic for gums and that usually margin repositioning and finishing at intrasulcular level are performed with the aid of fine-grained rotatory burs in combination with various soft tissue retraction techniques we had to find out a new atraumatic procedure. Finally using those instruments it is unavoidable to damage the marginal periodontal tissue causing bleeding and possible gingival recession and making it impossible taking an accurate impression during the same clinical session.[20, 21] On the opposite ultrasonic tools allow greater control by the operator, without getting gingival wounds during sulcus penetration and intracrevicular finish line preparation and polishing.[22] Really they selectively cut hard tissue preserving soft tissue, which remains undamaged if touched. This item was demonstrated as well during sinus lift surgery when ultrasonic tip touches Schneider's membrane.[23]

In fact, using piezoelectric ultrasonic vibration (25-30 kHz), ultrasonic devices precisely cut only mineralized structures (dental tissue and bone) without cutting soft tissues, which remain undamaged even in case of contact. The ultrasonic insert permits gentle finishing of dental tissue without damaging gums so that the risk of soft tissue recession due to possible mechanical damage would be avoided, especially in patients with thin periodontal biotype.

However in piezoelectric surgery there are some important disadvantages in comparison to traditional procedures: cut slowness and pression related heat production are the most important.

In particular, as for the traditional technique, heat production can invalidate surgery procedures and osteointegration, causing healing difficulties[24-26] or bone necrosis in cooperation with some others factors.[27]

The increase of temperature can be investigated also in ultrasonic prosthodontic applications.

Literature shows that temperature augmentation could compromise pulp integrity.[28-32]

According to Cohen's paper[33] more than 5.5 °C of temperature increase could be cause of pulp damages. The passing of this limit determines pulp incremental reactions, until irreversible damages, necrosis and abscesses. The *in-vitro* investigation is very important to fix some limits, knowing that *in-vivo* pulp reactions could be reduced by blood and saliva presence.[34]

For a clinician is very important knowing the potential temperature damage to pulp both during finishing line repositioning and polishing.

The aim of this study is to investigate the increase of temperature during finishing line repositioning and polishing using ultrasonic inserts and to verify if it remains within the limit of 5.5 °C.

Materials and methods

As first 32 extracted tooth have been prepared, lower and upper molar without caries or restorations pulled out due to periodontal causes.

Initial prosthodontic preparation and endodontic treatment have been standardized by silicone index. An endodontic treatment has been performed until apex preparation of 0.4 mm to allow a better thermo couple passage, then each tooth has been prepared with a round chamfered bur (6881.314.016 Komet, Lemgo, Germany) on a red ring handpiece to obtain a circumferential standard reduction of 0,8 mm and putting finishing line 2 mm coronally to cementum-enamel junction (Figure 1).

The apex has been mantained available for heat measure. Every tooth has been inserted in a stone box.

CrownPrep and TipHolder systematic (Mectron, Carasco, Genoa, Italy) used with MultiPiezo device (Mectron, Carasco, Genoa, Italy)

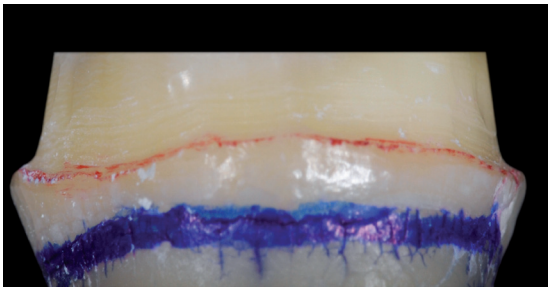

Figure 1.—Round chamfered bur tooth preparation (upper line, red in the online vesione), finishing line 2 mm coronally to cementum-enamel junction (lower line, blue in the online version).

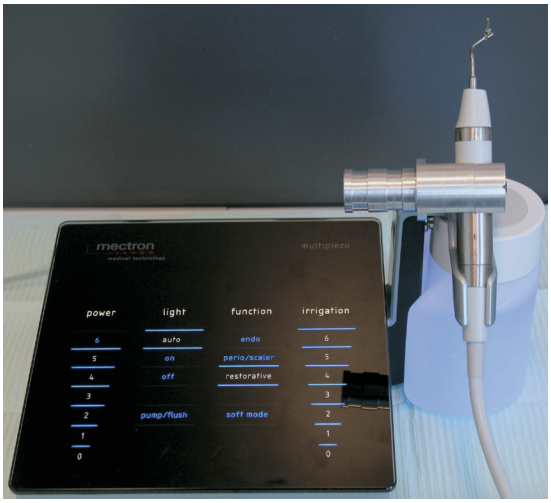

Figure 2.—MultiPiezo device.

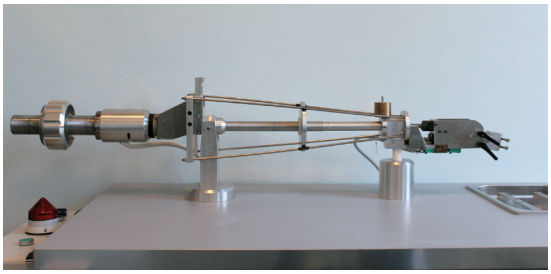

Figure 3.—Robotic arm.

(Figure 2) has been used for the finishing line repositioning (tip TA16D120 (Mectron, Carasco, Genoa, Italy) and polishing phases (tip TA16D60 (Mectron, Carasco, Genoa, Italy) (Figure 3).

According to manufacturer instructions, ultrasonic device is settled on Restorative function, Irrigation level 6 and power level 5.

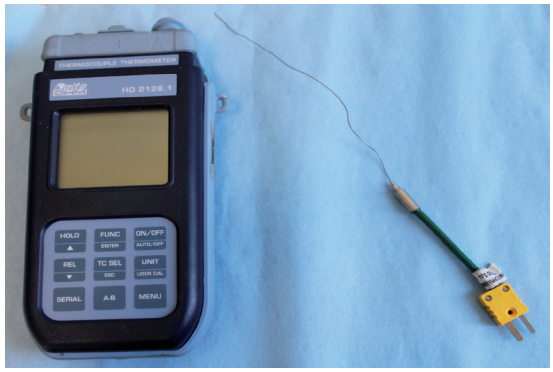

Figure 4.—A two way thermocouple.

Human dependent variables have been standardized by a robotic arm (Figure 3), in particular movement repetitiveness and pressure, fixed in 90 g for the repositioning and 60 g for the polishing.

Both finishing and polishing tip worked on tooth surfaces performing 32 rides 5 mm length, in according with mean tooth dimensions. During rides an irrigation of about 28-30 mL/min was maintained.

A two-way thermocouple (k HD2128.1, Delta ohm, Italy) (Figure 4) inserted in the endodontic space and linked to a software (DeltaLog, Genoa, Italy) was able to measure the variations of temperature during each ride. A table with 32 results for each instrument was obtained and named group 1 (tip Ta16D120) and group 2 (tip TA16D60) to perform a blind statistical analysis.

Statistical analysis

Statistical descriptive analysis about temperature has been performed by mean, standard deviation, medium, maximum and minimum. Due to asymmetric data distribution nonparametric Kruskal-Wallis test has been used, followed by Mann-Withney *post-hoc* test, without Bonferroni correction.

Results

Collected temperature data were inserted in a table and sent to statistical analysis (Table I).

The descriptive analysis shows that group 1 (tip TA16D120) implicates a less average temperature increment than group 2 (tip TA16D60).

TABLE I.—*Temperature data of group 1 and 2.*

Tooth	ΔT (°C)	
	Group 1	Group 2
1	5.65	8.65
2	4.40	5.30
3	5.55	5.55
4	5.35	5.50
5	4.85	5.30
6	3.00	5.20
7	4.00	6.10
8	5.30	5.25
9	5.45	4.35
10	5.45	4.80
11	3.60	4.70
12	5.30	4.75
13	5.60	5.20
14	5.00	5.05
15	5.40	5.40
16	5.00	5.70
17	4.40	6.35
18	5.20	5.20
19	4.70	6.30
20	4.15	5.55
21	4.25	6.10
22	5.70	4.40
23	4.70	4.85
24	5.20	5.80
25	2.70	4.60
26	5.05	5.10
27	2.15	5.20
28	4.75	6.55
29	4.90	6.00
30	4.95	4.65
31	2.05	4.45
32	5.20	4.90

Temperature variations were correlated between two groups through Mann-Withney Test (P value<0.001) and it shows no statistically differences between the two groups (P value=0.013) (Table II, Figure 5).

TABLE II.—*Descriptive data analysis and P value.*

	Group 1	Group 2	P value
Mean	4.65	5.40	Overall: <0.001
Standard deviation	0.99	0.84	Group 1 *vs.* group 2
Median	4.97	5.23	=0.013
Minimum	2.05	4.35	
Maximum	5.70	8.65	

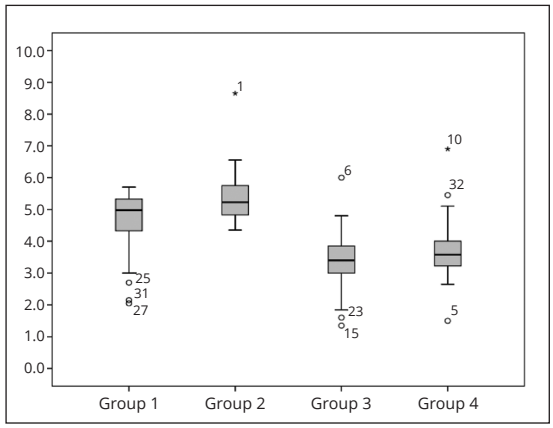

Figure 5.—Data distribution with indication of mean, standard deviation, minimum and maximum.

Discussion

Baldi *et al.* showed that the use of ultrasonic tips is advantageous because soft tissues are never damaged and prosthetic phases are optimized.[10]

The attention has to be focused on evaluation of potential pulp damages. As demonstrated in the past a temperature increment of 5.5 °C starts to be damaging for dental pulp with various steps that could determine pulp necrosis and abscesses.

The analysis of data shows that *in vitro* the use of ultrasonic tips to repositioning finishing line and polishing tooth preparations is totally safe for dental vitality.

The average of temperature variations remains in a range of safety.

Although the extra fine diamond tip seems to be more dangerous, probably because of less thickness of diamond coating, causes more friction and heat production.

It is important to underline that an *in-vitro* analysis surely gives an higher heat production. In fact, as demonstrated by Laurely *et al.*,[34] *in vivo* the presence of blood and saliva gives a stopgap effect that limits temperature increase.

The most important criteria to do a safe work are: pressure applicated during tooth preparations and tips cooling.

Massironi showed that, using red ring handpieces, a correct pressure is between 40 and 90 g. It is presumably a good parameter also in relation to ultrasonic instruments, in according with our results. In fact applying stronger pressures in traditional tooth preparation intrapulpar temper-

ature grows esponentially[35] and surely it could happened in ultrasonic preparations too.

The cooling is a crucial factor. A lot of studies show that an insufficient or wrong cooling bring a very strong temperature augmentation.[28, 36-38] So it is important maintaining a correct cooling flow included between 30 and 40 mL/min.[39] The water temperature could be lower than 30 °C.[40]

In conclusion it seems that the most important recommendation for clinicians would be to use a correct working pression and a strong control on cooling flow.

Following these recommendations it is possible to achieve best results and preserving pulp integrity.

Conclusions

Within the limitations of an *in-vitro* study, the ultrasonic prosthodontic applications show to be safe on maintaining pulp integrity.

The *in-vitro* analysis show that the pulp temperature increasing remains within the safe limits literature shows. It is important underline the polishing phase is the most critical and the clinicians have to pay attention to irrigation and pression to avoid pulp damages.

Additional clinical studies have to be performed to confirm these results and monitoring them.

References

1. Chen YL, Chang HH, Chiang YC, Lin CP. Application and development of ultrasonics in dentistry. J Formos Med Assoc 2013;112:659–65.

2. Schlee M, Steigmann M, Bratu E, Garg AK. Piezosurgery: basics and possibilities. Implant Dent 2006;15:334–40.

3. Vercellotti T. Technological characteristics and clinical indications of piezoelectric bone surgery. Minerva Stomatol 2004;53:207–14.

4. Van Der Weijden F. The power of ultrasonics. Berlin: Quintessence Books; 2007.

5. Homiak AW, Cook PA, DeBoer J. Effect of hygiene instrumentation on titanium abutments: a scanning electron microscopy study. J Prosthet Dent 1992;67:364–9.

6. Menini M, Piccardo P, Baldi D, Dellepiane E, Pera P. Morphological and chemical characteristics of different titanium surfaces treated by bicarbonate and glycine powder air abrasive systems. Implant Dent 2015;24:47–56.

7. Ellis R, Bennani V, Purton D, Chandler N, Lowe B. The effect of ultrasonic instruments on the quality of preparation margins and bonding to dentin. J Esthet Restor Dent 2012;24:278–85.

8. Horne P, Bennani V, Chandler N, Purton D. Ultrasonic margin preparation for fixed prosthodontics: a pilot study. J Esthet Restor Dent 2012;24:201–9.

9. Sous M, Lepetitcorps Y, Lasserre JF, Six N. Ultrasonic sulcus penetration: a new approach for full crown preparations. Int J Periodontics Restorative Dent 2009;29:277–87.

10. Baldi D, Menini M, Colombo J, Lertora E, Pera P. Evaluation of a New Ultrasonic Insert for Prosthodontic Preparation. Int J Prosthodont 2017;30:496–8.

11. Baldi D, Menini M, Pera F, Ravera G, Pera P. Sinus floor elevation using osteotomes or piezoelectric surgery. Int J Oral Maxillofac Surg 2011;40:497–503.

12. Schierano G, Vercellotti T, Modica F, Corrias G, Russo C, Cavagnetto D, *et al.* A 4-Year Retrospective Radiographic Study of Marginal Bone Loss of 156 Titanium Implants Placed with Ultrasonic Site Preparation. Int J Periodontics Restorative Dent 2019;39:115–21.

13. Stacchi C, Lombardi T, Baldi D, Bugea C, Rapani A, Perinetti G, *et al.* Immediate Loading of Implant-Supported Single Crowns after Conventional and Ultrasonic Implant Site Preparation: A Multicenter Randomized Controlled Clinical Trial. BioMed Res Int 2018;2018:6817154.

14. Vercellotti T, Stacchi C, Russo C, Rebaudi A, Vincenzi G, Pratella U, *et al.* Ultrasonic implant site preparation using piezosurgery: a multicenter case series study analyzing 3,579 implants with a 1- to 3-year follow-up. Int J Periodontics Restorative Dent 2014;34:11–8.

15. Baldi D, Colombo J, Schierano G, Carossa S, Rebaudi A, Pesce P, Pera P. Piezoelectric implant surgery and immediate loading in the aesthetic zone. Minerva Stomatol 2019;68(5):217–25.

16. Menini M, Dellepiane E, Baldi D, Longobardi MG, Pera P, Izzotti A. Microarray expression in peri-implant tissue next to different titanium implant surfaces predicts clinical outcomes: a split-mouth study. Clin Oral Implants Res 2017;28:e121–34.

17. Menini M, Dellepiane E, Chvartszaid D, Baldi D, Schiavetti I, Pera P. Influence of different surface characteristics on peri-implant tissue behavior: A six-year prospective report. Int J Prosthodont 2015;28:389–95.

18. Baldi D. Longobardi M, Cartiglia C, La Maestra S, Pulliero A, Bonica P, Micale RT, Menini M, Pera P, Izzotti A. Dental implants osteogenic properties evaluated by cDNA microarrays. Implant Dent 2011;20:299–305.

19. Baldi D, Lombardi T, Colombo J, Cervino G, Perinetti G, Di Lenarda R, *et al.* Correlation between Insertion Torque and Implant Stability Quotient in Tapered Implants with Knife-Edge Thread Design. BioMed Res Int 2018;2018:7201093.

20. Massironi D, Pascetta R, Romeo G. Estetica e Precisione. Milan: Quitessenza edizioni; 2004.

21. Wilson RD, Maynard G. Intracrevicular restorative dentistry. Int J Periodontics Restorative Dent 1981;1:34–49.

22. Massironi D. Optimizing the prosthetic margin with sonic instrumentation. Dent Today 2011;30:152, 154–5.

23. Baldi D, Menini M, Pera F, Ravera G, Pera P. Sinus floor elevation using osteotomes or piezoelectric surgery. Int J Oral Maxillofac Surg 2011;40:497–503.

24. Mishra SK, Chowdhary R. Heat generated by dental implant drills during osteotomy-a review: heat generated by dental implant drills. J Indian Prosthodont Soc 2014;14:131–43.

25. Gupta V, Pandey PM, Gupta RK, Mridha AR. Rotary ultrasonic drilling on bone: A novel technique to put an end to thermal injury to bone. Proc Inst Mech Eng H 2017;231:189–96.

26. Rashad A, Kaiser A, Prochnow N, Schmitz I, Hoffmann E, Maurer P. Heat production during different ultrasonic and conventional osteotomy preparations for dental implants. Clin Oral Implants Res 2011;22:1361–5.

27. Izzotti A, Menini M, Pulliero A, Dini G, Cartiglia C, Pera P, *et al.* Biphosphonates-associated osteonecrosis of the jaw: the role of gene-environment interaction. J Prev Med Hyg 2013;54:138–45.

28. Langeland K. Effect of various procedures on the human dental pulp. Pulp reactions to cavity preparation and gutta purcka. Oral Surg Oral Med Oral Pathol 1961;14:210–33.

29. Lefkowitz W, Robinson HB, Postle HH. Pulp response to cavity preparation. J Prosthet Dent 1958;8:315–24.

30. Murray PE, Windsor LJ, Smyth TW, Hafez AA, Cox CF. Analysis of pulpal reactions to restorative procedures, materials, pulp capping, and future therapies. Crit Rev Oral Biol Med 2002;13:509–20.

31. Nyborg H, Brännström M. Pulp reaction to heat. J Prosthet Dent 1968;19:605–12.

32. Viţalariu A, Căruntu ID, Bolintineanu S. Morphological changes in dental pulp after the teeth preparation procedure. Rom J Morphol Embryol 2005;46:131–6.

33. Zach L, Cohen G. Pulp response to externally applied heat. Oral Surg Oral Med Oral Pathol 1965;19:515–30.

34. Laurell KA, Carpenter W, Daugherty D, Beck M. Histopathologic effects of kinetic cavity preparation for the removal of enamel and dentin. An in vivo animal study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1995;80:214–25.

35. Cavalcanti BN, Otani C, Rode SM. High-speed cavity preparation techniques with different water flows. J Prosthet Dent 2002;87:158–61.

36. Anil N, Keyf F. Temperature change in the pulp chamber during application of heat to composite and amalgam cores and its returning time to oral heat. Int Dent J 1996;46:362–6.

37. Ercoli C, Rotella M, Funkenbusch PD, Russell S, Feng C. In vitro comparison of the cutting efficiency and temperature production of ten different rotary cutting instruments. Part II: electric handpiece and comparison with turbine. J Prosthet Dent 2009;101:319–31.

38. Laforgia PD, Milano V, Morea C, Desiate A. Temperature change in the pulp chamber during complete crown preparation. J Prosthet Dent 1991;65:56–61.

39. Oztürk B, Uşümez A, Oztürk AN, Ozer F. In vitro assessment of temperature change in the pulp chamber during cavity preparation. J Prosthet Dent 2004;91:436–40.

40. Thomas MS, Kundabala M. Pulp hyperthermia during tooth preparation: the effect of rotary—instruments, lasers, ultrasonic devices, and airborne particle abrasion. J Calif Dent Assoc 2012;40:720–31.

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