Original Article

The Comparison of Silver and Laser Soldering Techniques on Periodontal Tissues: A Preliminary Study

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ABSTRACT

Objective: The aim of this study was to compare the inflammatory effects of conventional and laser soldering methods on periodontal tissues in orthodontics.

Materials and Method: Forty specimens were acquired from 10 patients whose treatment plan consisted of extraction of 4 first premolars. Before performing the extractions, a transpalatal arch (TPA) for the upper first molars and a lingual arch for the lower first molars were placed for anchorage purposes. Upper left and lower right first molar bands were soldered using the laser welding (LW) technique, and upper right and lower left first molar bands were soldered using the conventional silver soldering technique (CSS). Gingival crevicular fluid (GCF) analysis was used for determining the effects of welding procedures on periodontal tissues. All variables were analyzed by nonparametric tests.

Results: Myeloperoxidase levels ranged between 2.46 and 3.56 for the CSS group and between 2.20 and 3.39 for the LW group; nitric oxide levels ranged between 4.92 and 7.13 for the CSS group and between 4.39 and 6.78 for the LW group. Both levels showed the highest level on the seventh day. Plaque index and gingival index scores ranged between 0 and 1 for all specimens. Bleeding on probing levels ranged between 45% and 75% and between 60% and 75% for the CSS group and LW group, respectively.

Conclusion: There was no significant difference between laser welding and conventional soldering methods in terms of periodontal tissue response. (*Turkish J Orthod* 2014;27:70–75)

KEY WORDS: Conventional silver soldering, Gingival crevicular fluid, Laser welding

INTRODUCTION

In orthodontics, bonded attachments are used routinely as part of fixed appliance therapy. However, molar bands still remain popular instead of bonded tubes, especially for anchorage purposes.[1,2] The joining of a metal framework is commonly necessary to create individual orthodontic appliances.[3] Conventional orthodontic soldering is defined as joining the parent metals with different types of metals over a temperature of 450°C.[4,5]

Soldering of the joints is generally performed using a hand-held butane torch. The use of a butane torch generates electrochemical hydrogen-oxygen flame, which is the main agent for soldering parent metals.[6] The main problems of the conventional soldering are galvanic corrosion, low biocompatibility, and low mechanical strength because of brazing gaps.[7] Porosities resulting from deficient filling of the solder gap and corrosion properties confirm the need for alternative joining techniques, such as laser welding.[5] However, conventional silver soldering is

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To cite this article: Atik E, Dursun CK, Akcan CA, El H, Tözüm TF, Ciğer S. The comparison of silver and laser soldering techniques on periodontal tissues: a preliminary study. *Turkish J Orthod*. 2014;27:70–75 (DOI: http://dx.doi.org/10.13076/TJO-D-14-00013)

Date Submitted: March 2014. Date Accepted: July 2014.

the most preferred welding method in orthodontics since it is cost-effective compared to other welding methods, and compared with laser welding, it does not require technique-specific equipment.

In contemporary orthodontics, an alternate method for joining metal frameworks is laser welding.[8,9] Crystals of yttrium aluminum garnet (YAG) doped with neodymium (Nd) are mainly used to emit laser beams (Nd:YAG laser) in order to weld dental alloys.[10–13] This procedure creates a concentration of heat at the welding point, which in turn causes local melting of the metal. Laser welding technology offers numerous advantages, among which are working efficiency, corrosion-resistant solder-free joint technology, homogeneous structure, high mechanical strength, small area affected by heat, work near plastic and ceramic materials, easy connection, and suitability for practically all dental alloys and titanium.[14,15] Besides these advantages, currently, these industrial machines are still characterized by their large size, high cost, and fixed-lens beam delivery systems which limit their use mostly to dental technician laboratories.

The solder alloys that are used most commonly are made up of silver, copper, and zinc. These metallic ions are considered to be dangerous chemical products since they are included in the list of substances and processes with great risks for human life.[16] The use of different alloys as welding material can induce oxidation processes and in this manner can initiate metal ions to release due to the corrosion of the metal surface.[17] Sestini *et al*.[18] showed that silver soldering had detrimental effects on osteoblast differentiation and fibroblast viability. Grimmsdottir *et al*.[19] speculated that cytotoxic corrosion products from orthodontic appliances might contribute to localized gingivitis.

When the inflammatory process around natural teeth is of concern, nitric oxide (NO) is a short-lived, highly reactive free radical produced from L-arginine involved in a variety of cellular pathways.[20] Increased levels of gingival NO synthases during periodontal inflammation have been reported compared with noninflamed gingival tissue.[21,22] Myeloperoxidase (MPO) is another inflammatory enzyme that is a major constituent of the azurophilic granules of polymorphonuclear leukocytes (PMNs) and oxidizes chloride ions to the strong oxidant hypochlorus acid (HOCl), the most bactericidal oxidant produced by neutrophils.[23] Being an indicator of PMN infiltration, gingival crevicular fluid MPO is associated with the severity of periodontal inflamation.[24]

The aim of this study is to compare the effects of 2 different soldering modalities (laser welding and conventional silver soldering) on periodontal tissues by analyzing the clinical periodontal parameters as well as NO and MPO activity in the gingival crevicular fluid.

MATERIALS AND METHODS

This study protocol was approved by the ethical committee of Hacettepe University in March 2011. Ten patients (4 female patients with a mean age of 14.4 years and 6 male patients with a mean age of 15.3 years) who were referred to the Department of Orthodontics, Hacettepe University, were examined in this study. The sample was selected from among the patients who had a severe crowding (with a mean crowding amount of 6.43 mm) in both maxillary and mandibular arches and Class I skeletal relationship and whose treatment plan consisted of extraction of 4 first premolars. Exclusion criteria included patients having oral habits detrimental to health such as smoking, first molar teeth having restorations and/or caries, and severe accumulation of calculus and plaque due to bad oral hygiene. Prior to all clinical procedures, patients were instructed in brushing or other hygiene measures by an experienced periodontist. Patients and their parents were provided with detailed information of the study protocol, and their informed consent was obtained.

A transpalatal arch (TPA) for the upper first molars and a lingual arch for the lower first molars were placed for anchorage purposes. A standardized orthodontic band without molar tubes (unwelded lower and upper first molar band, Dentaurum, Ispringen, Germany) to wire (round 0.9 mm stainless steel, hard for TPA, Dentaurum) joint configuration was used. During the fabrication process, upper left and lower right first molar bands were soldered using the laser welding (LW) technique, and upper right and lower left first molar bands were soldered using the conventional silver soldering technique (CSS) as shown in Figure 1. In all, 40 specimens were obtained from 10 patients. All of the conventional silver soldering and laser welding specimens were fabricated by the same researcher and applied by an experienced orthodontist. None of the extractions were carried out until the last day of sampling procedures.

Gingival Crevicular Fluid Sampling

During clinical measurements, gingival crevicular fluid (GCF) samples were collected from the mesial, distal, buccal, and palatinal aspects of every banded molar tooth before appliance insertion and 1, 3, 7, 14, 21, and 30 days following the banding procedure. For GCF sampling, the "orifice" method was used as described by Rüdin *et al*.[25] After sampling, the GCF was measured in Periotron units, which were converted to microliters by MLCONVRT.EXE software (Oraflow Inc, Smithtown, NY, USA). To eliminate the risk of evaporation, strips with GCF were placed in sterile, firmly wrapped Eppendorf tubes immediately and stored at −20°C until the day of laboratory analysis. GCF samplings were performed by the same periodontist.

Clinical Examination

The clinical status of the molar teeth was evaluated by use of plaque index (PI), gingival index (GI), and bleeding on probing (BOP) percent. All measurements were performed at 4 sites around each banded molar tooth. Clinical parameters were recorded by the same periodontist and were repeated at 1, 3, 7, 14, 21, and 30 days following the banding procedure during follow-up.

Biochemical Analysis

Using a microplate for the determination of nitrite levels, 100 μL of the extract was mixed with 0.5 mL of Greiss reagent. After 10 minutes of incubation at room temperature, the absorption of each sample in microplate wells was determined at 540 nm.[26] MPO were determined by commercially available enzyme-linked immunosorbent assay (ELISA) kits (Calprotectin, BMA Biomedicals, Augst, Switzerland; MPO, Immundiagnostik, Bensheim, Germany).

Statistical Analysis

The power of the sample size was calculated by using the G*Power 3 program (Institut für Experimentelle Psychologie, Düsseldorf, Germany), and it was determined that 40 samples would be needed to conduct this study with 85% power (α=0.05).[27] Due to the nonnormal distribution of the data according to Kolmogorov-Smirnov test, changes of the clinical parameters and the gingival crevicular fluid parameters were analyzed by nonparametric tests. Spearman correlation coefficient was calculated to evaluate interrelations between both biomarkers. Statistical significance was defined as $p < 0.05$. A software program (SPSS 11.0 for Windows, SPSS Inc, Chicago, IL, USA) was used for all calculations.

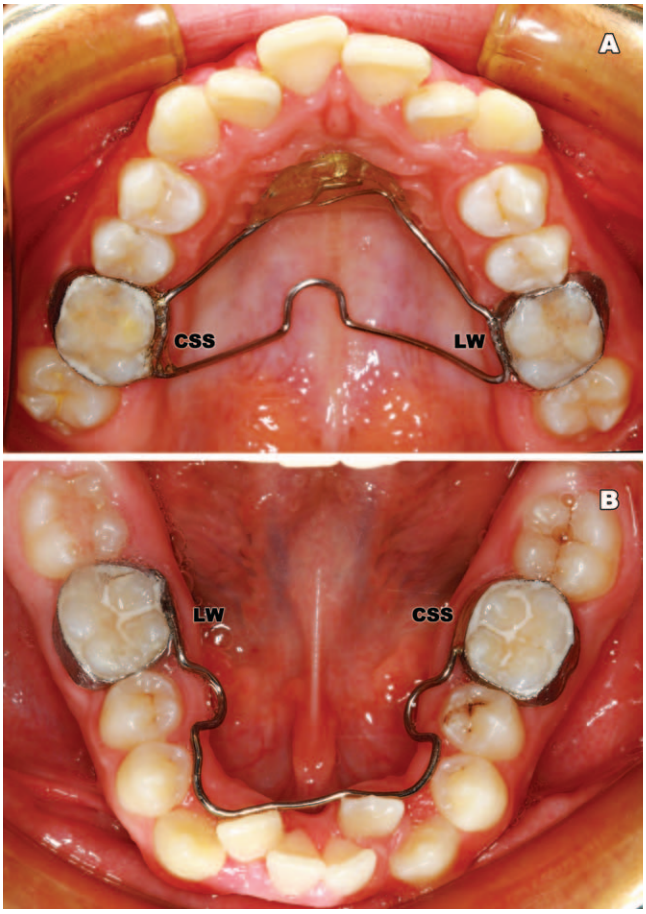

Figure 1. Application of (A) transpalatal arch and (B) lingual arch. Lower left and upper right molar bands were silver soldered, lower right and upper left molar bands were laser welded.

RESULTS

Data for clinical parameters, gingival crevicular fluid markers, and comparative statistical analysis for conventional and laser welding groups during 1-month follow-up are summarized in Table 1. In all, 10 patients (20 LW and 20 CSS) were followed up in a 1-month period.

During 1-month follow-up, there were no significant differences for volume of the GCF between the LW and CSS groups.

Instead of the baseline time, the highest PI and GI scores for the LW and CSS groups were observed at day 21. No significant differences in GI and PI scores were observed for any time intervals between the LW and CSS groups. The highest BOP score was observed at day 21 and at day 7 for the CSS

Table 1. Descriptive statistic values and comparison of the soldered and welded specimens using Mann-Whitney *U* test[a]

N = 20		Day 0 (Mean ± SD)	Day 1 (Mean ± SD)	Day 3 (Mean ± SD)	Day 7 (Mean ± SD)	Day 14 (Mean ± SD)	Day 21 (Mean ± SD)	Day 30 (Mean ± SD)
Volume	CSS	0.18 ± 0.06	0.22 ± 0.12	0.20 ± 0.10	0.18 ± 0.08	0.19 ± 0.09	0.21 ± 0.11	0.22 ± 0.11
	LW	0.24 ± 0.13	0.22 ± 0.10	0.22 ± 0.10	0.18 ± 0.08	0.24 ± 0.12	0.26 ± 0.11	0.21 ± 0.09
	p	0.21	0.83	0.58	0.75	0.10	0.08	0.90
PI	CSS	0.96 ± 0.47	0.45 ± 0.29	0.59 ± 0.58	0.46 ± 0.27	0.48 ± 0.36	0.75 ± 0.75	0.64 ± 0.57
	LW	0.83 ± 0.47	0.49 ± 0.39	0.63 ± 0.48	0.61 ± 0.38	0.51 ± 0.30	0.72 ± 0.63	0.70 ± 0.70
	p	0.31	0.90	0.53	0.20	0.62	0.95	0.87
GI	CSS	0.76 ± 0.46	0.66 ± 0.55	0.54 ± 0.47	0.48 ± 0.50	0.56 ± 0.57	0.66 ± 0.546	0.59 ± 0.365
	LW	0.70 ± 0.59	0.58 ± 0.61	0.46 ± 0.35	0.59 ± 0.32	0.58 ± 0.35	0.76 ± 0.750	0.69 ± 0.555
	p	0.64	0.53	0.68	0.12	0.40	0.90	0.74
BOP	CSS		70%	60%	45%	65%	75%	75%
	LW		60%	65%	75%	75%	75%	75%
	p		0.74	0.74	0.53	0.49	1.00	1.00
NO	CSS	5.71 ± 5.23	6.22 ± 8.14	6.53 ± 6.03	7.13 ± 5.68	5.36 ± 3.70	4.92 ± 3.31	6.43 ± 7.12
	LW	4.55 ± 3.19	4.61 ± 3.19	5.13 ± 4.16	6.78 ± 4.89	5.59 ± 6.76	4.39 ± 3.61	5.62 ± 3.88
	p	0.47	0.89	0.50	0.73	0.19	0.48	0.80
MPO	CSS	2.85 ± 2.62	3.11 ± 4.07	3.26 ± 3.01	3.56 ± 2.84	2.68 ± 1.85	2.46 ± 1.66	3.22 ± 3.56
	LW	2.27 ± 1.59	2.30 ± 1.59	2.57 ± 2.08	3.39 ± 2.44	2.79 ± 3.38	2.20 ± 1.80	2.81 ± 1.94
	p	0.47	0.89	0.50	0.73	0.19	0.48	0.80

[a] CSS indicates conventional silver soldering; LW, laser welding; PI, plaque index; GI, gingival index; BOP, bleeding on probing; NO, nitric oxide; and MPO, myeloperoxidase.
* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

and LW groups, respectively, and remained stable until the end of the experimental period.

The LW and CSS groups presented with similar increasing and decreasing trends regarding MPO and NO levels. The MPO and NO levels for the CSS and LW groups increased toward day 7, and the highest scores for both groups were noticed at day 7. These levels then decreased toward the end of the experimental period (day 30). At any experimental time interval, no significant difference ($p < 0.05$) was present regarding both total NO and MPO levels between the LW and CSS groups.

DISCUSSION

Orthodontic appliances are being used increasingly in young and adult patients, and it has been shown that the long-term presence of metals in the oral environment can be harmful to health. Mucosal ulcerations, severe irritations, and allergies to nickel caused by orthodontic appliances, especially associated with soldered joints, have been reported.[28,29] As well as a low mechanical strength with high failure rates, conventional silver-soldered joints show problems of galvanic corrosion and possible biocompatibility.[30] In order to overcome these shortcomings, the laser welding technique, which is a technology based on using infrared light spectrum, has been introduced and become a well-accepted welding technique in dentistry. When searching the literature for laser welding, we found no study on the inflammatory effects of welding techniques on periodontal tissues *in vivo*. Therefore, we aimed to design an *in vivo* study to compare the effects of 2 different soldering modalities on periodontal tissues by analyzing the MPO and NO activity in the gingival crevicular fluid and evaluating the clinical parameters (PI, GI, and BOP) taken at different time intervals.

During interval periods, all patients participated in a hygiene phase, including supragingival scaling, polishing of all teeth, and repeated oral hygiene instructions. Thus, the effects of oral hygiene differences between patients on periodontal measurements were eliminated. GCF analysis was used for determining the effects of welding procedures on periodontal tissues. GCF is found at the gingival sulcus, which is a serum-like fluid exudate from capillaries and includes many diagnostic metabolic markers, which can show the degree of the inflammatory reactions. As active tooth movement may affect the diagnostic metabolic marker in GCF, we inserted passive TPA and lingual arches, respectively, to the maxillary and mandibular arches so that metabolic markers in the GCF were only affected from welding procedures.

During 1-month follow-up there were no significant differences in volume of the GCF between the LW and CSS groups. Similar GCF volume at all times with 2 welding techniques is important in terms of showing the reliability of this study.

For periodontal indices (PI, GI), no significant differences were found between the 2 welding procedures. The highest PI and GI scores for the LW and CSS groups were observed at day 21. These scores reduced toward day 30. For both groups, PI and GI scores ranged between 0 and 1 for all specimens, which is an indicator of similar plaque control and gingival health between groups under healthy conditions.

The highest BOP score was observed at day 21 (75%) and at day 7 (75%) for the CSS group and LW groups, respectively. After these experimental time intervals, BOP scores were stable toward the end of the experimental period. No significant differences with regard to the periodontal indices (PI, GI, and BOP) between groups indicated that both welding procedures affected the periodontal tissue in a same manner at any time point.

MPO and NO levels presented similar trends of increase and decrease regarding 2 welding procedures. MPO levels ranged between 2.46 and 3.56 for the CSS group and between 2.20 and 3.39 for the LW group and showed the highest level on the seventh day. NO levels ranged between 4.92 and 7.13 for the CSS group and between 4.39 and 6.78 for the LW group and showed the highest level on the seventh day. The differences between groups according to MPO and NO levels were not significant. Increases in the levels of MPO and NO have been reported directly related to oxidative stress and gingival/periodontal inflammation.[31] According to our results, both welding procedures did not influence the local periodontal oxidant status.

CONCLUSION

The findings of this study showed that the effects of 2 different soldering modalities (laser welding and conventional silver soldering) on periodontal tissues analyzed by the MPO and NO activity in the gingival crevicular fluid and clinical parameters were not significantly different from each other. Further studies are needed with increased number of subjects in order to understand the possible impact of different soldering techniques on periodontal tissues.

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