Dental
Communication

Biosc.Biotech.Res.Comm. Special Issue Vol 13 No (8) 2020 Pp-565-569

BBRC
Bioscience Biotechnology
Research Communications

Comparison of Tensile Strengths of Welded Orthodontic Tubes Using Electrical Resistance and Argon Laser Welding

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ABSTRACT

The aim of this study was to compare the tensile strength of orthodontic tubes welded by conventional electrical resistance welding and argon laser welding procedures. Twenty specimens of molar tubes were divided into two groups (n=10); group 1; electrical resistance welding, group 2; argon laser welding. The tensile strengths were measured using an INSTRON universal testing machine. Statistical analysis was performed using the SPSS software. Independent t test was done to compare the variables.The means and standard deviations of tensile strength for the groups were calculated. The mean tensile strength value of electrical resistance welding was 387.35+/-114.49 and that of argon laser welding was 492.10+/-151.99.There was no statistical significant difference between the two groups although argon laser showed higher values in terms of tensile strength. (P value - 0.099) In conclusion, argon laser welding had higher tensile strengths when compared to electrical resistant welding but not statistically significant.

KEY WORDS: LASER WELDING, ELECTRICAL RESISTANCE WELDING, TENSILE STRENGTH, ORTHODONTIC BANDS..

INTRODUCTION

Bands in orthodontics have been in use for more than 100 years(Weinberger, 1926) Although bondable buccal tubes have gained popularity, a large number of Orthodontists still use bands with buccal tubes attached to them. The mode of attachment of these buccal tubes are important because the tensile strength of this attachment would determine failure of the attachment leading to considerable delay in orthodontic treatment.

ARTICLE INFORMATION

*Corresponding Author: orthoravi2@gmail.com
Received 2nd Aug 2020 Accepted after revision 28th Sep 2020
Print ISSN: 0974-6455 Online ISSN: 2321-4007 CODEN: BBRCBA

Thomson Reuters ISI Web of Science Clarivate Analytics USA and Crossref Indexed Journal

Clarivate Analytics

crossref

NAAS Journal Score 2020 (4.31) SJIF: 2020 (7.728)

*Online Contents Available at: http//www.bbrc.in/
Doi: http://dx.doi.org/10.21786/bbrc/13.8/198*

In orthodontics, there are several ways by which attachments or auxiliaries can be joined. These include, Brazing, Soldering, Welding, Electrical resistance welding, Laser welding, Tungsten inert gas welding, etc. Although several methods of joining attachments have been proposed, resistance spot welding and soldering have been the most commonly used procedures. Soldering involves the use of a filler material between two closely approximated components and is a technique sensitive procedure. Welding on the other hand is a simpler procedure and involves the passage of current through resistant weldmates to achieve fusion. Due to its simplicity, welding is more commonly used(Pattabiraman et al., 2014).

Laser welding also offers other benefits such as high mechanical strength, reduced distortion due to a narrow heat affected zone, least contamination with oxide free part, faster process time, corrosion resistant joint, and no galvanic effect due to welding without third material.

In addition, laser welded joints proved to be superior as compared to a soldered one in terms of biocompatibility. It is also reported that laser welding remaining with the joint behaves to be 100% hypoallergenic, non-reactive and insoluble in oral environment(Perveen, Molardi and Fornaini, 2018). Laser welding of other attachments to orthodontic wires have been studied and have shown sufficient strength of the joint without altering the material properties and hence shown clinical efficacy. (Solmi et al., 2004). Both laser and Tungsten Inert Gas welding are solder-free alternatives to joining metal Tungsten inert gas welding has a lower investment cost and is comparable with laser welding..(Bock et al., 2008). There is no reported study in literature that compares laser welding and resistance spot welding methods in terms of tensile strength for attaching buccal tubes to molar bands.

Previously our team has done extensive research that ranged from epidemiological studies to randomised clinical trials that have been published in reputed journals.(Felicita and Sumathi Felicita, 2017a, 2017b) (Felicita and Sumathi Felicita, 2018)(Felicita et al., 2017)(Korath, Padmanabhan and Parameswaran, 2017) (Krishnan, Pandian and Rajagopal, 2017)(Charles et al., 2018)(Krishnan, Pandian and Kumar, 2018)(Reddy et al., 2018)(Chinnasamy et al., 2019). This knowledge was instrumental for us to study the tensile strength of welded orthodontic tubes using argon laser welding and electrical resistance welding. The aim of this study was to compare the tensile strength of orthodontic tubes welded by conventional electrical resistance welding and argon laser welding procedures

MATERIAL AND METHODS

A total of 20 new metal bands were used to which 20 buccal tubes were welded with electric resistance spot welding (n = 10) and laser welding (n = 10). Standardized orthodontic band to buccal tube configuration was used. The type of buccal tube and band used are shown in figure 1. Twenty molar bands were embedded into standardized acrylic blocks and the buccal tubes were welded onto them using Electrical spot welding and Argon Laser welding. The fracture strength measurement of different welding methods was carried out using an INSTRON universal testing machine. During the test, the loading was continued until the welded joint broke into two pieces. Additionally, the tensile test was terminated when the gap between pieces reached 2 mm even if no fracture occurred.The determined tensile strength was then tabulated and compared. Statistical analysis was performed with the SPSS software and an independent t test was done to compare the variables.The means and standard deviations of tensile strength for the groups were calculated.

Welding procedures :
Group 1 : The buccal tube was taken and welded to the molar band by electrical resistance welding as in figure 2.
Group 2 : The buccal tube was taken and welded to the molar band by argon laser welding as shown in figure 3.

The tensile bond strength was calculated using a universal testing instron machine as shown in figure 4.

Figure 1: Orthodontic Molar Tube

Figure 2: Electrical resistance welder

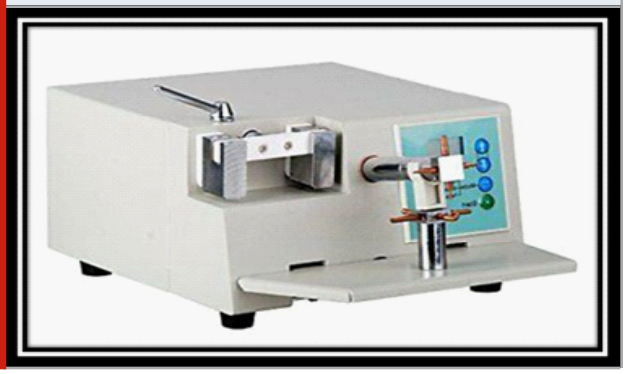


Figure 3: Argon Laser welder

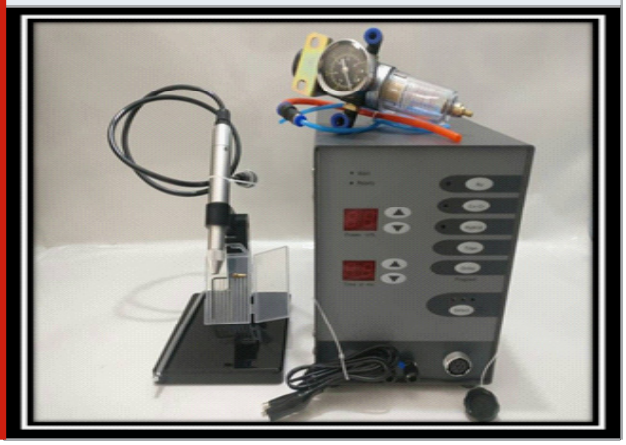
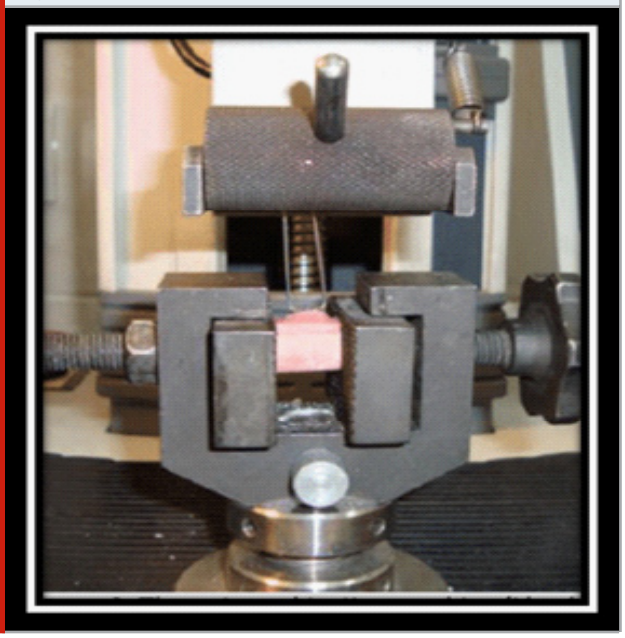


Figure 4: Molar tube held in the INSTRON machine



RESULTS AND DISCUSSION

The tensile strength of the electrical welding group and the laser welding group have been tabulated in Table 1 and Table 2 respectively. The mean, standard deviation and standard error have been tabulated in Table 3. The mean tensile shear strength value of electrical resistance welding was 387.35 +/- 114.49 and that of argon laser welding was 492.10+/-151.99. There was no statistical significance between the two groups although argon laser showed higher values in terms of tensile strength. Figure 5 shows the mean and standard deviation of the two groups. It is inferred that the Argon laser Welding has a higher mean tensile strength than Electrical resistant welding, but it was not statistically significant. P value - 0.099 (P>0.05)

Table 1. Tensile strengths of electrical resistant welding - Group 1

Electrical Resistance Welding Group:1	Tensile Strength [Mpa]
1	313.54
2	432.55
3	345.36
4	567.356
5	603.64
6	267.66
7	345.65
8	278.1
9	356.89
10	362.76

Table 2. Tensile strengths of Argon Laser welding - Group 2

Argon Laser Welding Group:2	Tensile Strength [Mpa]
1	498.3
2	522.11
3	478.56
4	623.16
5	768.54
6	438.09
7	513.56
8	196.24
9	348.78
10	533.67

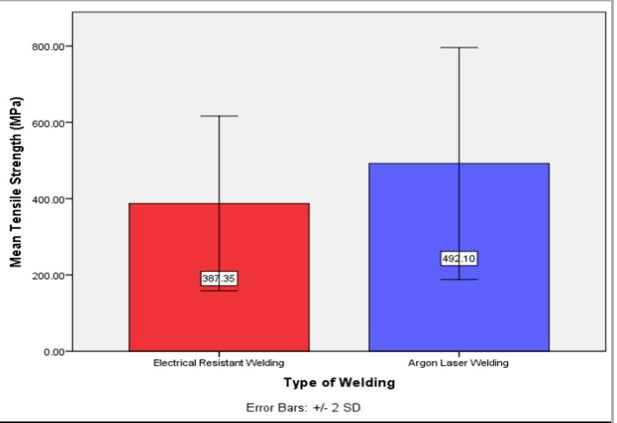
Table 3. Descriptive Statistics of the tensile strengths of the tested welded molar tubes.

Groups		N	Mean	Std. Deviation	Std. Error Mean
Tensile Strength	ELECTRICAL RESISTANT WELDING	10	387.35	114.49	36.20
	ARGON LASER WELDING	10	492.10	151.99	48.06

Molar bands have been one of the most important components of fixed orthodontic treatment. Buccal tube positions play an important role in delivering force vectors. Although, preformed bands have been used commonly now, the advantage of being able to change force vectors due to differential positioning of buccal tubes remains.The use of buccal tube positioning to prevent extrusion of molar teeth and to alter buccal tube positioning for class II dental finish cases are known and hence the need for attaching buccal tubes through different welding methods seems to be of utmost importance. No studies till date have assessed the tensile strengths of buccal tubes attached to bands with electrical spot welding and laser welding. Hence this study was

conducted with the aim of comparing the two common methods of welding buccal tube attachments. This study was conducted on 10 samples each, welded by electrical spot welding and Argon laser welding respectively. The result of an independent t-test showed no statistical significance among the two groups although the values were higher for the Argon laser welding group. (P value - 0.099)

Figure 5: Bar graph showing the mean tensile strength scores (MPa) and the standard deviation of the two groups. (Electrical resistant welding and Argon laser welding). The X-axis represents the two types of welding used and the Y-axis represents the mean tensile strength of the two groups in MPa. An independent t-test was done and it was inferred that the Argon laser Welding has a higher mean tensile strength than Electrical resistant welding, but it was not statistically significant. P value - 0.099 (P>0.05).



Conventional methods of joining buccal attachments like soldering have been largely replaced by methods such as electrical spot welding and laser welding due to their lesser toxicity and ease of use. Previous studies have been conducted on attachment to orthodontic wires using different methods of welding , testing their tensile bond strength and other characteristics of attachment. (Nascimento et al., 2012)(Iijima, Brantley, Yuasa, Muguruma, et al., 2008)(Iijima, Brantley, Yuasa, Kawashima, et al., 2008). Conclusions from these studies have shown that both these types of welding show desirable characteristics with lasers being more clinically efficient due to concentrated areas of heating but have been used less due to factors considering affordability. Sessini et al(Sestini et al., 2006) compared in vitro toxicity of resistance spot welding, laser welding and soldering and found highest toxicity for silver soldering and good tolerance for resistance welding and laser welding. In some studies, laser welded joints showed greater mechanical resistance than that achieved by traditional welding.(Fornaini et al., 2010)

Laser Beam Welding (LBW has advantages such as a corrosion resistant technology without solder, it eliminates any galvanic effect because the weld is done with the parent metal without the introduction of additional metals, little or no heat transfer to the local structures increasing the versatility of the technology, and more accurate than the conventional soldering techniques and it is a non-contact welding method. In laser welding, laser light is focused on small regions, applying high energy to these areas in a very short amount of time. Heating is mainly focused at the point of application; therefore the surrounding areas do not damage.These would be the added advantages in favour of laser welding along with the results of this study. The limitations of this study include a small sample size, and hence, future studies with a larger sample size would provide more accurate results. Parameters other than the tensile strength could be assessed for a comprehensive analysis.

CONCLUSION

From this study, it can be concluded that there is no difference in the tensile strength between electrical resistance welding and argon laser welding of orthodontic buccal tubes to molar bands.

ACKNOWLEDGEMENTS

I would like to record my deep sense of gratitude to my research supervisor Dr. Ravindra Kumar Jain, Reader, Department of Orthodontics, Saveetha Dental College and Hospitals, Chennai for his inspiring guidance and encouragement with my work during all stages. There was an equal contribution from all the authors.

Conflict of Interest: There is no conflict of interest.

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