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FRACTURE LOAD OF SILVER SOLDERED JOINTS ON STAINLESS STEEL AND COBALT-CHROMIUM ORTHODONTIC WIRES WITH VARIOUS JOINING CONFIGURATIONS

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ABSTRACT

The current research compared and analysed the tensile strength of silver soldered stainless steel and cobalt-chromium orthodontic wire joints with band material The effect of joint site planning on various orthodontic joining configurations was investigated. A total of sixty wire specimens were chosen, thirty in the stainless-steel group and thirty in the cobalt – chromium group. Again, each group's sample was divided into three subgroups, namely End – End, Round, and Orthodontic band material. The study findings suggested all three configurations can be used to make silver soldered joints regardless of the wire consistency. When subjecting the wire to joint site planning, however, stainless steel wire should be used with its limitations in mind.

Keywords: Silver Soldered Joint, Stainless Steel, Cobalt -Chromium, Fracture Load, Joint Configuration.

INTRODUCTION

The reliability of silver weld joints used in the fabrication of space maintainers and orthodontic appliances is important for the performance of the appliances (Gawlik et al., 1996, & O'Toole, 1985). Unplanned office visits are obliged by broken equipment. Complications of broken equipment include inflammation of the soft tissue, lost anchorage, immovable teeth and swallowing or aspiration of broken parts. New methods and materials for helping dentists manufacture better, silver soldered joint is targeted with research. Different authors have assessed the tensile strength of soldered joints differently from the incorporation of different orthodontic techniques.

Cobalt-Chromium Wire is currently favoured over stainless steel for space holding appliances and techniques where loops in arch wires are used. However, Co-Cr wire thermal processing results in a wire with Stainless steel (Dua & Nandlal, 2004) like properties. Tensile bending and torsional measures are usually used to determine the mechanical properties of these wires. Although these tests do not necessarily represent the wire characteristics of these wires under clinical conditions, they form a basis for a comparison of these wires.

The objective of this study was therefore to compare and assess the fracture load of the silver-soldered joint of the orthodontic stainless steel and cobalt chromium with the band material and in a variety of orthodontic joints (Brown et al., 1982 & Cattaneo, et al., 1992).

MATERIALS

Two types of wires and band materials used to test the tensile strengths of silver soldered joints in the study.

Table 1. Material and Brand used for study

S.I NO.	MATERIAL	BRAND
1.	20 gauge /0.9 mm round stainless steel	Leon
2.	20 gauge /0.9 mm round cobalt-chromium	Leon
3.	0.18”x.005” stainless steel band materials	Orthotic
4.	Silver solder	Dentaurum,hard solder(working temperature 610 degree celsis/1130 degree F)
5.	Flux	Dentaurum

Table 2. Equipment and brand used for study

S.I NO.	EQUIPMENT	BRAND
1.	Gas air flame	Jaypee
2.	Testing machine - UTM	Make:Hounsefield U.K Model:50KM Capacity: 50KN
3.	Wooden jig	In order to stabilize the wire and band material

Armamentarium

Wire cutter, universal plier, band cutting scissors diamond disc, measuring scale, tweezer, plaster of paris, jig , aluminium blocks, rubber bowl.

METHODS

The specimens were organized in the postgraduate laboratory of the Department of Orthodontics at JSS Dental College and Hospital in Mysore. Tests were conducted at Sri Jayachamarajendra

University of Engineering, Mysore, Department of Polymer Science and Technology. In the analysis, the tensile strength of silver soldered joints was tested using two types of wires and the stainless-steel band material. 0.9 mm, 0.9mm, 0.9mm cobalt – chromium wire (leon), and ring material of stainless steel (0.018"x.005") (ortho-organiser).

The tensile strength of silver soldered joints was evaluated by preparing sixty specimens, thirty in stainless steel and thirty in cobalt-chromium (Cheng et al., 1993) Every group's sample was divided equally into three sub-groups: end to end (25mm in length), round (25mm in length), and orthodontic band (25mm in length). Plaster of Paris blocks were used to shield areas other than the joint site from excessive exposure to heat from the soldering torch (Chaves et al., 1998 & Cheng et al., 1994). For soldering all joints, Dentaurum silver solder and flow have been used. After application of the flux the joint site was adequately heating with flame reduction zone (Gardiner, J. H., & Aamodt, A. C., 1969). (Piezo gas burner 2000, Japanese) and 6 mm solder was kept in a tweezer and injected into the joint site when the solder flow temperature was reached (O'Toole et al., 1985 & Brown et al., 1982). During the soldering process, the flame was held approximately 3/4 cm long. The light was removed by the solder in a feathering edge configuration flown over the joint site. All specimens, suggested by Phillips (1991) were immediately quenched in cold water. Measurements of joints with tensile force were performed by means of a Universal Testing Machine (make Hounsefield U.K. Model 50KM 50KN) with standardized crosshead speed of 2.00mm/min.

The failure load was measured in Newtons. The broken samples were visually examined in the solder joint, wire or band fracture respectively to determine where failure occurred (Gulker et al., 1994). For the comparison of the tensile strength strength of silver soldered joints, the tensile strength values in N/mm of the joint longitude were then determined / measured.

Figure 1. Wire

Figure 2. Armamentarium

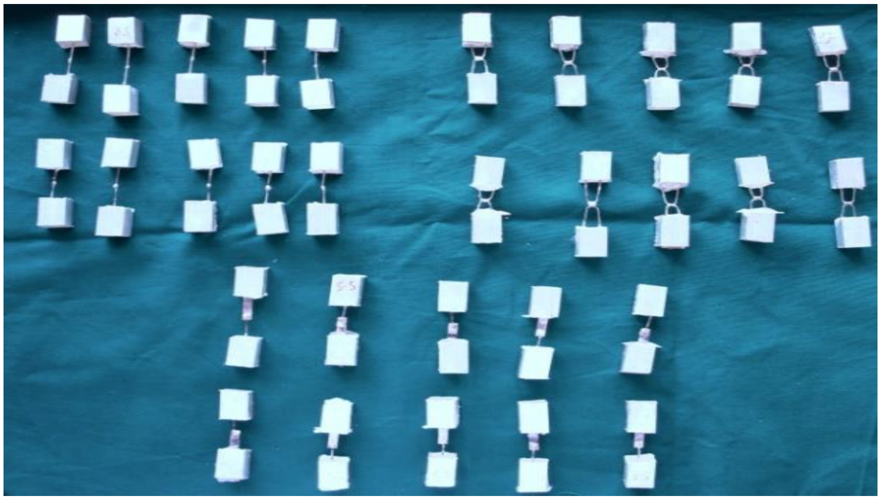

Figure 3. Specimens End – End, Round, and Orthodontic band material.

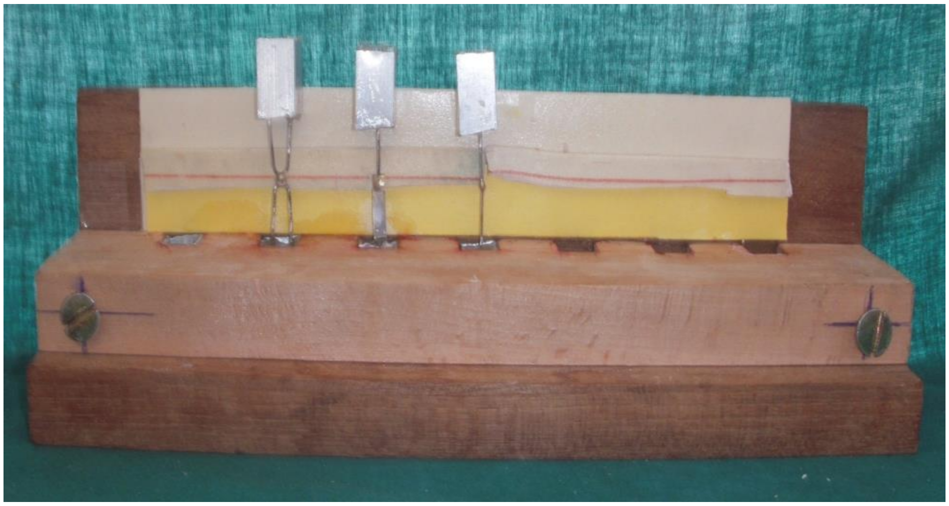

Figure 4. jig

RESULTS

Statistical analysis – independent samples test was performed.

The mean tensile strength values of soldered joints for the various groups i,e., cobalt-chromium(Co-Cr) and stainless steel(S.S) in the study ,
Co-Cr (End to End, Round & Wire to band) - 232.42 N/mm, 388.45N/mm & 62.46N/mm respectively and S.S (End to End, Round & Wire to band) - 232.5N/mm, 382.99N/mm & 59.12N/mm respectively.
Hence mean tensile strength cobalt-chromium was superior compared with that of stainless steel (Round and band to wire configuration).

Comparison of tensile strength of soldered joints on various configuration of Co-Cr and S.S wires groups

a. End to End -Independent samples test (table 3) was conducted for different wire groups and it revealed that between different wires a no significant difference existed in their mean tensile strength values of soldered joints at 0.05 & 0.01 level (F= value 2.396, p=0.984 >0.05 and 0.01)

b. Round- Further , on same test (table 4) was conducted it revealed that between different wires, a significant difference existed in their mean tensile strength values of soldered joints @ 0.05 & 0.01 level(F=0.587, P=0.001 < than 0.05 & 0.01)

c. Band to wire, (table 5) no significant difference existed in their mean values of soldered joints @ 0.05 & 0.01 level (F=0.122, P=0.046 > than 0.05 &0.01)

Fracture site determination
Determination of fracture site (Figure 5, 6) for various wire groups have been discussed separately later, since no statistical tests have been applied on the observed values.

Table 3. Group and independent samples test – wire (co-cr and S.S) in End to End group

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
End to End	Co-Cr	10	232.4200	5.16673	1.63386
	S.S	10	232.5000	10.98079	3.47243

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
End to End	Equal variances assumed	2.396	.139	-.021	18	.984	-.08000	3.83762	-8.14253	7.98253
	Equal variances not assumed			-.021	12.799	.984	-.08000	3.83762	-8.38393	8.22393

Since the P value which is 0.984 is greater than 0.05 and 0.01 there is no significant difference in End to End at 5% and 1% level of significance

Table 4. Group and independent samples test – wire (co-cr and S.S) in Round group

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Round	Co-Cr	10	388.4500	2.64249	.83563
	S.S	10	382.9900	3.21505	1.01669

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Round	Equal variances assumed	.587	.454	4.149	18	.001	5.46000	1.31603	2.69512	8.22488
	Equal variances not assumed			4.149	17.349	.001	5.46000	1.31603	2.68767	8.23233

Since the P value which is 0.001 is less than 0.05 and 0.01 there is significant difference in Round at 5% and 1% level of significance

Table 5. Group and independent samples test – wire (co-cr and S.S) in Band group

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Band	CoCn	10	62.4600	3.25993	1.03088
	SS	10	59.1200	3.68142	1.16417

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Band	Equal variances assumed	.122	.731	2.148	18	.046	3.34000	1.55499	.07308	6.60692
	Equal variances not assumed			2.148	17.740	.046	3.34000	1.55499	.06965	6.61035

Since the P value which is .046 is less than 0.05 and greater than 0.01 there is significant difference in Band at 5% and not significant at 1% level of significance

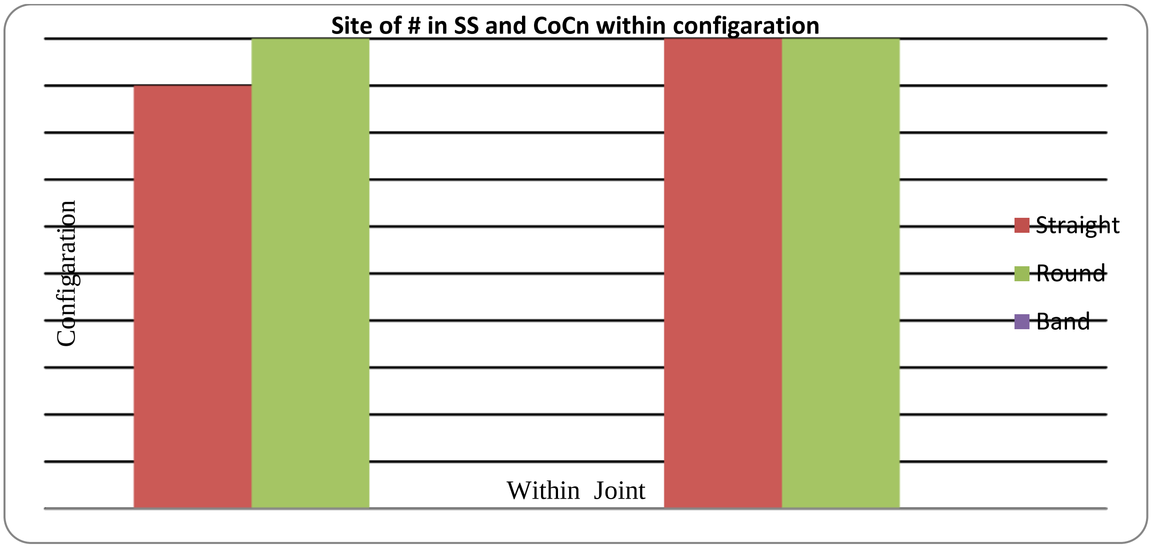

Figure 5. Fracture site determination between straight and round configuration

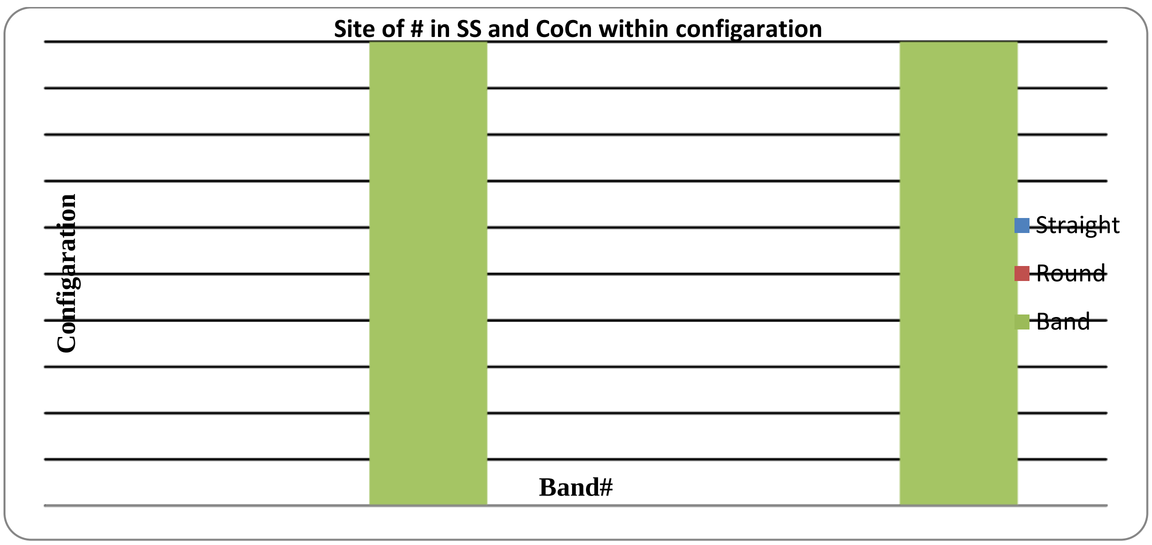

Figure 6. Fracture site determination between wire (S.S & CoCn) and band

DISCUSSION

Silver soldering of wires for appliance welding usually requires wire overlap with bands, crowns, and other wires. It is important that the solder wraps around the wires for the comparatively weak solder to have enough mass to stabilize the joint (Laird & Von Fraunhofer, 1972; Verde & Stein, 1994). The solder's edges should be feathered onto the wire so that no crack is left for agents to reach and begin a corrosive action (Tehini & Stein, 1993). According to the evidence, no alloying occurs at the stainless steel-silver solder interface, and the bond is purely mechanical (Wiskott et al., 1997). The tensile strength of a silver soldered joint is affected by the joint's design, metallurgy, and stress distribution within the joint. The joint strength should ideally be the same as the parent metals being joined, but if intermetallic layers form at the metal / solder interface, weakening effects can occur. However, the interatomic force between the solder and the parent metal (wire / band material) is far greater than that of either the parent metal or the solder (Phillips, 1991 & Rogers, 1979). As a result, fracture occurs within the weaker material. As loops in arch wires are used in the construction of appliances, Co-Cr wire is now favoured over S.S wire. Co-Cr wires may be soldered in the same manner as S.S wires. It has also been discovered to be easier to control than stainless steel cables. As a result, Co-Cr was included as one of the wire groups in the report.

The topic has been divided into sections for ease of understanding and convenience.

The mean tensile strength values of soldered joints for the various groups i,e., cobalt-chromium(Co-Cr) and stainless steel(S.S) in the study .1

Co-Cr (End to End, Round & Wire to band) - 232.42 N/mm, 388.45N/mm & 62.46N/mm respectively and S.S (End to End, Round & Wire to band) - 232.5N/mm, 382.99N/mm & 59.12N/mm respectively.

Determination of site of fracture

All specimens were visually examined to determine where the failure had occurred outside the solder joint (wire, band material or within it)

a. For Co-Cr wire soldered end to end joint configuration all 10 samples tested for tensile strength fracture within joint and in S.S wires End to End joints out of 10 samples maximum fractured within joint one sample experienced a wire fracture

b. Both Co-Cr & S.S were soldered as Round joints configuration all samples fractured within the joint.

c. Both Co-Cr & S.S were soldered to band material all fractured at the band site unavoidable overheating of stainless-steel band material, which destroys its temper and resiliency as well as its lower tensile strength, may have resulted in more band fractures. However, in order to reach a proper conclusion, additional research with band material and wire of equivalent tensile strength must be performed.

CONCLUSION

Based on the findings, it is possible to infer that all three materials, namely S.S, Co-Cr, and band content, can be used to prepare silver soldered joints regardless of wire properties and consistency. When subjecting the wire to joint site planning, however, Gloria (S.S.) wire should be used with its limitations in mind.

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REFERENCES

Brown, T., Mitchell, R., & Barenie, J. (1982). Evaluation of five silver soldering techniques. *The Journal of pedodontics*, *6*(3), 235-243.

Cattaneo, G., Wagnild, G., Marshall, G., & Watanabe, L. (1992). Comparison of tensile strength of solder joints by infrared and conventional torch technique. *The Journal of prosthetic dentistry*, *68*(1), 33-37.

Chaves, M., Vermilyea, S. G., Papazoglou, E., & Brantley, W. A. (1998). Effects of three soldering techniques on the strength of high-palladium alloy solder joints. *The Journal of prosthetic dentistry*, *79*(6), 677-684.

Cheng, A. C., Chai, J. Y., Gilbert, J., & Jameson, L. M. (1994). Investigation of stiffness and microstructure of joints soldered with gas-oxygen torch infrared methods. *The Journal of prosthetic dentistry*, *72*(1), 8-15.

Cheng, A. C., Chai, J. Y., Gilbert, J., & Jameson, L. M. (1993). Mechanical properties of metal connectors soldered by gas torch versus an infrared technique. *Journal of Prosthodontics*, *2*(2), 103-109.

Dua, R., & Nandlal, B. (2004). A comparative evaluation of the tensile strength of silver soldered joints of stainless steel and cobalt chromium orthodontic wires with band material—an in vitro study. *J Indian Soc Pedod Prev Dent*, *22*, 13-6.

Gawlik, J. A., Mathieu, G. P., & Hondrum, S. (1996). The effects of tack welding and increasing surface area on the tensile strength of silver electric and flame soldered stainless steel joints. *Pediatric dentistry*, *18*, 215-218.

Gardiner, J. H., & Aamodt, A. C. (1969). Some aspects of soldering stainless steel. A metallurgical investigation. *The Dental practitioner and dental record*, *20*(2), 65-76.

Gulker, I. A., Martini, R. T., Zinner, I. D., & Panno, F. V. (1994). A comparison of hydrogen/oxygen and natural gas/oxygen torch soldering techniques. *International Journal of Prosthodontics*, *7*(3).

Laird, W. R., & Von Fraunhofer, J. A. (1972). Silver soldered joints in stainless steel. A comparative evaluation of techniques. *British dental journal*, *132*(7), 263-267.

O'Toole, T. J., Furnish, G. M., & Von Fraunhofer, J. A. (1985). Tensile strength of soldered joints. *The Journal of prosthetic dentistry*, *53*(3), 350-352.

Phillips, R. W. (1991). Wrought base metal alloys wrought gold alloys. In skinners science of dental materials. *Philadelphia: WB Saunders Co*, 537-57.

Rogers, O. W. (1979). A metallographic evaluation of the stainless steel-silver solder joint. *Australian dental journal*, *24*(1), 13-16.

Tehini, G. E., & Stein, R. S. (1993). Comparative analysis of two techniques for soldered connectors. *The Journal of prosthetic dentistry*, *69*(1), 16-19.

Verde, M. A. L., & Stein, R. S. (1994). Evaluation of soldered connectors of two base metal ceramic alloys. *The Journal of prosthetic dentistry*, *71*(4), 339-344.

Wiskott, H. W. A., Macheret, F., Bussy, F., & Belser, U. C. (1997). Mechanical and elemental characterization of solder joints and welds using a gold-palladium alloy. *The Journal of prosthetic dentistry*, *77*(6), 607-616.