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Comparative Evaluation of The Fracture Load Of Silver Soldered Joints On Various Orthodontic Joining Configuration Of Stainless Steel and Cobalt-Chromium Orthodontic Wires" – An Invitro Study.

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Abstract
The present study was conducted to compare and evaluate the tensile strength of silver soldered joints of stainless steel and cobalt-chromium orthodontic wires with band material . An attempt was made to observe the effect of joint site preparation on various orthodontic joining configuration . A total of sixty wires specimens were selected out of them, thirty in stainless steel group and thirty in cobalt – chromium group Again in each group sample were equally divided into three-sub groups i.e., End – End ,Round and to Orthodontic band material.
The findings of the study were suggestive that all three configuration may be used for preparing silver soldered joints irrespective of the quality of the wire. However when subjecting the wire to joint site preparation, S.S wire should be used keeping its limitations in view.

Key Words
Fracture Load, Silver Soldered Joints, Orthodontic Joining Configuration, Stainless Steel, Cobalt-chromium.

Introduction

The strength of silver soldered joints used to fabricate space maintainers and orthodontic appliances is critical to their success[1,2]. The appliance must be able to withstand the forces generated while masticating. Broken appliances compel patients for unscheduled office visits. Complications of broken appliances include soft tissue irritation, lost orthodontic anchorage, untoward movement of teeth and swallowing or aspiration of broken parts[1]. Research is meagred in terms of new materials and methods to help dental surgeons to fabricate stronger silver soldered joints. Various authors have evaluated different soldering techniques than the incorporation of different orthodontic wires to study the tensile strength of soldered joints.

For space holding appliances and in techniques where loops in arch wires are used cobalt-chromium wire is presently preferred over stainless steel. But heat treatment of Co-Cr wire results in a wire with properties similar to S.S[3].

The mechanical properties of these wires are generally assessed by tensile bending and torsional tests. Although wire characteristics determined by these tests do not necessarily reflect the behaviour of these wires under clinical conditions, they provide a basis for comparison of these wires.

Hence, The Aim of The this Study was to Compare and Evaluate the Fracture Load of Silver Soldered Joints of Stainless Steel and Cobalt Chromium Orthodontic Wires with Band Material and In Various Orthodontic Joining configuration.

Materials And Methods :

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

Materials:

1	20 Gauge/0.9 Mm Round Stainless Steel (Fig 1)	Leon
2	20 Gauge/0.9 Mm Round Cobalt-chromium (Fig 1)	Leon
3	0.18"x.005" Stainless Steel Band Materials (Fig 2)	Orthotic
4	Silver Solder (Fig 2)	Dentaurum, Hard Solder (Working Temp. 610 Degree Celsis/1130 Degree F)
5	Flux (Fig 2)	Dentaurum

Equipment :

1	Gas Air Flame (Fig 2)	Jaypee
2	Testing Machine (Fig 5)	UTM Make:Hounsefield U.K, Model: 50km, Capacity:50kn
3	Wooden Jig (Fig 4)	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 assorted in the post graduate laboratory of the dept of orthodontics , j.s.s dental college and hospital,mysore

The tests were carried out at the dept of polymer science and technology, sri jayachamarajendra college of engineering ,mysore

Two types of wires and stainless steel band material were used to test the tensile strength of silver soldered joints in the study.

Orthodontic stainless steel wire(H.P) 0.9 mm , 0.9mm cobalt – chromium wire (leon) **(Fig 1)** and stainless steel band material

Fig. 1: Wires

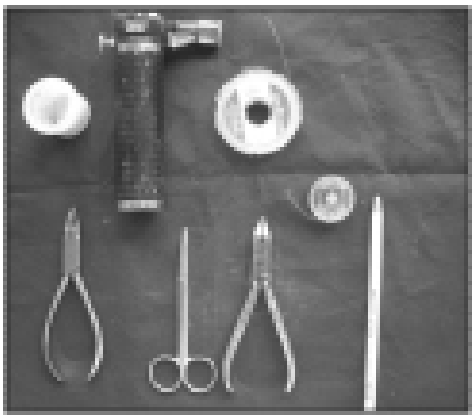


Fig. 2: Armamentarium

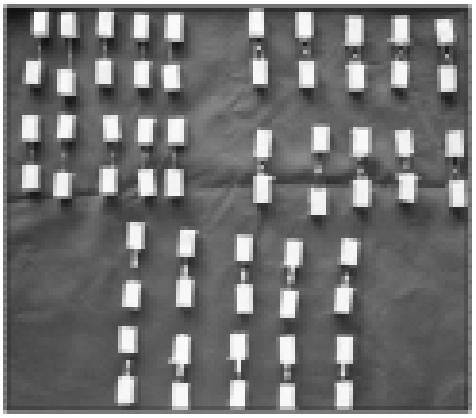


Fig. 3: Specimens

(.018"x.005") (ortho-organiser). **(Fig 2)**

The tensile strength of silver soldered joints was tested by preparing a total of sixty specimens out of them , thirty in stainless steel group and thirty in cobalt-chromium group. In each group sample were equally divided into three sub-group i.e., End to End (25mm in length), Round(25mm in length), and to orthodontic band (25mm in length) **(Fig 3)**. Areas other than joint site were protected unnecessary exposure to heat from the soldering torch by plaster of paris blocks. Dentaurum silver solder and flux were used for soldering all joints. The joint site was adequately heated after application of the flux, with the reducing zone of the flame (Piezo gas burner2000,Japanese) and as soon as the site reached solder flow temperature, 6mm of solder was held in a tweezer and
introduced at the joint site. The flame was kept approximately 3/4th inch long throughout the soldering procedure. The flame was withdrawn when the
solder had flown over the joint site in a feather edge configuration. All specimens were immediately quenched in cold water as recommended by Phillips14. Tensile strength measurements were made of the

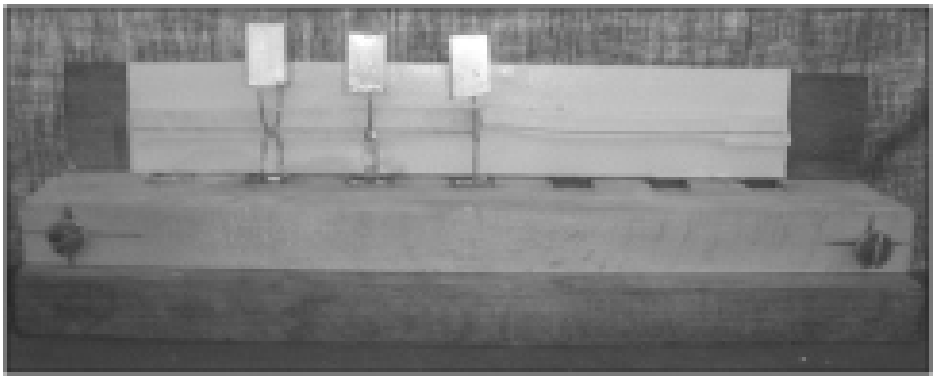


Fig. 4: Wooden Jig

Fig. 5: Universal Testing Machine (UTM)

joints using a Universal Testing Machine (Make: Hounsefield U.K., Model 50KM with a capacity of 50KN) **(Fig 5)** with a uniform crosshead speed of 2.00mm/min.

The load at failure was recorded in Newtons. The broken samples were examined visually to determine where the failure had occurred, within the solder joint, wire or band fracture respectively. The tensile strength values in N/mm of the joint length were then determined / calculated for comparative evaluation of the tensile strength of silver soldered joints.

Results-

Statistical analysis – independent samples test was performed.

1. **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-

TABLE 1 End to End Configuration

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
End to End	Co-Cr	10	232.42	5.16673	1.63386
	S.S	10	232.5	10.98079	3.47243

Since the P value which is 0.984 is greater than 0.05 and 0.01

there is no significant difference in

EndtoEnd at 5% and 1% level of significance

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	0.139	-0.021	18	0.984	-0.0800	3.83762	-8.14253	7.98253
	Equal variances not assumed			-0.021	12.799	0.984	-0.0800	3.83762	-8.38393	8.22393

TABLE 2 Round Configuration

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Round	Co-Cr	10	388.4500	2.64249	0.83563
	S.S	10	382.9900	3.21505	1.01669

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

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	0.587	0.454	4.149	18	0.001	5.46000	1.31603	2.69512	8.22488
	Equal variances not assumed			4.149	17.349	0.001	5.46000	1.31603	2.68767	8.23233

TABLE 3 Wire and Band Configuration

Group Statistics

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

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.

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	0.122	0.731	2.148	18	0.046	3.34000	1.55499	0.07308	6.60692
	Equal variances not assumed			2.148	17.740	0.046	3.34000	1.55499	0.06965	6.61035

chromium was superior compared with that of stainless steel (Round and band to wire configuration).

2. 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 1)** 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 2)** 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 3)** 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)

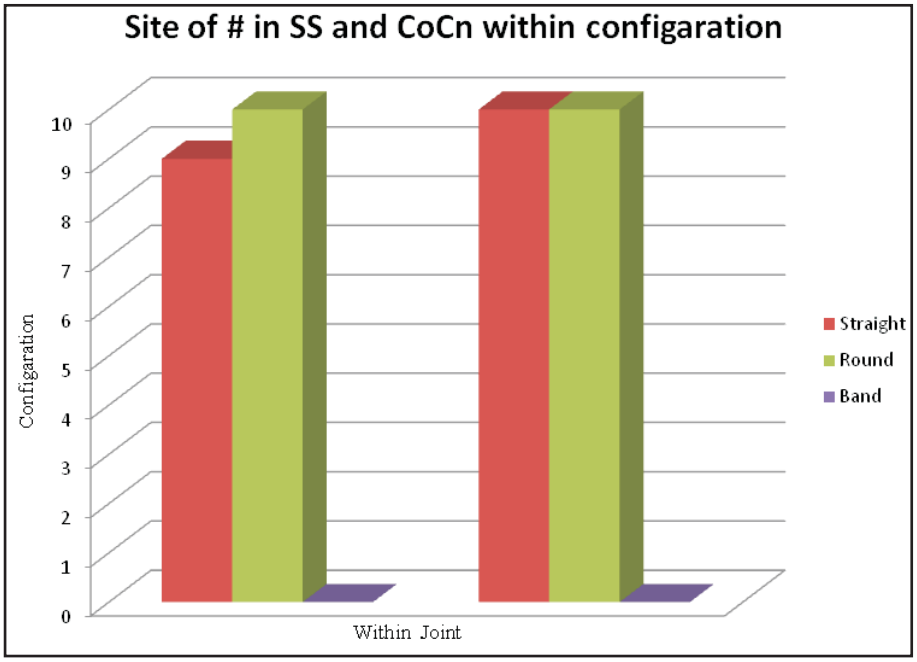
3. Fracture Site Determination

Determination of fracture site **(Graph 1,2)** for various wire groups have been discussed separately later , since no statistical tests have been applied on the obsereved values.

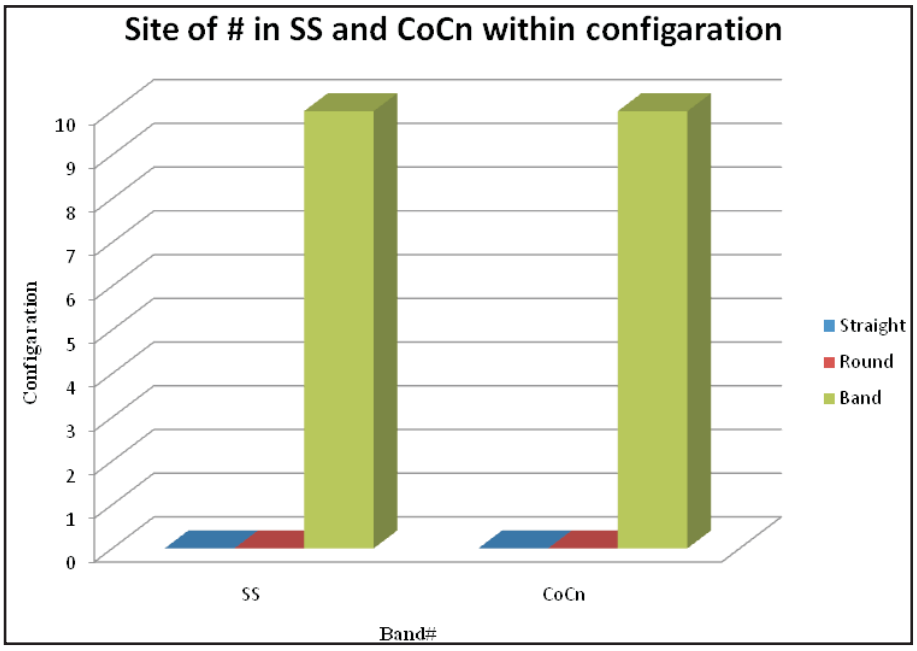
Discussion:

Silver soldering of wires for the fabrication of appliances typically involves overlap of wires with bands, crowns and other wires. It is important that the solder wraps around the

Graph 1,2



Graph 1- Site Of Fracture In Stainless Steel And Cobalt-chromium Within Configuration (With In Joints- End To End And Round Configuration)



Graph 2- Site Of Fracture In Stainless Steel And Cobalt Chromium Within Configuration (Wire And Band Configuration)

wires so that the relatively weak solder has sufficient mass to strengthen the joint. The edges of the solder ought to be feathered onto the wire so that no crack is left for agents to enter and start a corrosive action. Evidence indicates that no alloying occurs at the stainless steel-silver solder interface and that the bond is strictly mechanical.

The tensile strength of a silver soldered joint is affected by the design, of the joint, the metallurgy of the joint and the stress distribution within the joint. Ideally, the joint strength should be as great as that of the parent metals being joined although if intermetallic layers are formed at the metal / solder interface, weakening effects may result. In general though, the interatomic force between the solder and parent metal (wire / band material) is considerably greater than that of either the parent metal or the solder. Consequently fracture occurs within the weaker material

In fabrication of appliances when loops in arch wires are used Co-Cr wire is presently preferred over S.S Co-Cr wires possesses the ability to be soldered as S.S wires. It has also been found to be easier to manipulate than S.S wires. Hence Co-Cr was also incorporate as one of the wire groups in the study.

For proper comprehension and convenience the discussion has been dealt under the headings

1. **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 . (Table 1,2,3)**

   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.

2. **determination of site of fracture- (Graph 1,2)**

   All specemins were visually examined to determine whre 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 S.S band material which destroys its temper and resiliency along with its lower tensile strength may have led to more band

fractures. however in order to arrive proper conclusion , further research using band material and wire of comparable tensile need to be conducted.

Conclusion:

From the study it can be concluded that all the three material viz. S.S , Co-Cr , band material may be used for preparing silver soldered joints irrespective of the properties and quality of wire.-However when subjecting the wire to joint site preparation, Gloria (S.S.) wire should be used keeping its limitations in view.

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