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Research Article

COMPARISON OF PHYSICAL PROPERTIES OF COMMONLY USED STAINLESS STEEL ORTHODONTIC WIRES WITH RECENTLY INTRODUCED NEWER WIRES

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A R T I C L E I N F O

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A B S T R A C T

Introduction: Stainless steel wires have been the workhorse of the orthodontic profession for generations and have found great acceptance in modern day orthodontic treatment. The purpose of the present study is to evaluate and compare the physical properties, mainly the ultimate tensile strength and microhardness of the wires as well as to study the surface topography and crystalline structure.

Materials and Method: Seven types of wires were used in this study. To eliminate operator bias, each wire had been designated a particular alphabets In addition, scanning electron microscopic studies of the Crystalline structure at the fracture site and surface topography. Tests for comparing the tensile properties, micro hardness, surface topography and crystalline structure were performed.

Results

Tensile Properties

It is found that ultimate tensile strength and yield strength was highest for Wilcock wires and lowest for Dentaurum's super spring hard. The difference between means is very highly significant.

Microhardness

It is found that microhardness valuesWORD was highest for Wilcock's extra special test followed by special plus and lowest for T.P. Original wire premier plus.

Surface Topography

The qualitative assessment revealed that T.P. Original wire has a smooth surface finish and is also treated with a chemical cleanser.)

Fracture Characterization

Wilcock wires demonstrated a ductile type of fracture. Unisil demonstrated a cup and cone type of fracture.

Conclusion: The present study has revealed that laboratory tests alone do not seem capable of identifying major short comings of a new wire material. From this study, it appears that a combination of simple mechanical tests & electron microscopic studies, ought to be most relevant. However, to determine the exact properties of the wire, it must be subjected to in-vivo clinical conditions and then tested for various properties.

INTRODUCTION

Stainless steel wires have been the workhorse of the orthodontic profession for generations and have found great acceptance in modern day orthodontic treatment. Orthodontists demand, extremely diverse performance requirements from these wires, in their practices. The properties of these wires significantly affect the overall efficiency of clinical treatment.

Presently, the orthodontist may select from all the available wire types, one that best meets the demands of a particular clinical situation. The selection of an appropriate wire size and alloy type in turn, would provide the benefit of optimum and predictable treatment results. The clinician must therefore be conversant with the mechanical properties and relevant clinical applications of these properties, of the wires. Although several investigators have evaluated the mechanical properties of various wire types a cohesive clinical interpretation of these findings is lacking.

Until the 1930's the only orthodontic wires available, were made of gold. Stainless steel due to its greater strength, higher modulus of elasticity, good resistance corrosion and to economical, introduced into orthodontics in 1931, and since then has gained acceptance over gold

Aim and Objective

The aim and objective of this study was to evaluate and do a meaningful comparison of seven different types of stainless steel round wires commonly available in the market, having a mean diameter of 0.016 inch. The properties evaluated are

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1. Tensile properties
2. Micro hardness
3. Surface topography
4. Crystalline structure at the fracture site

MATERIALS AND METHODS

Materials

All the wires used in this particular study have a mean diameter of 0.016", dispensed and marketed in the form of spools. To eliminate operator bias, each wire has been designated a particular alphabet. A A.J. Wilcock Special plus B A.J. Wilcock Extra special plus C T.P. Original wire Premier D T.P. Original wire Premier plus E. Dentaurum Remanium Super spring hard F Dentaurum Remanium Super special spring hard G 3M/Unitek Unisil Light wire The intent of this particular study is to evaluate and compare the mechanical properties, mainly the ultimate tensile strength and micro hardness of some of the most commonly used stainless steel wires having a mean diameter of 0.016 inch.

In addition, scanning electron microscopic studies of the crystalline structure at the fracture site and surface topography was also undertaken.

Five samples were taken from each coded group for the study. This study was conducted in the Department of Orthodontics and Dentofacial Orthopaedics, Yenepoya Dental College, Mangalore.

All the physical tests were conducted at the Geological and Metallurgical Laboratories Ltd, Bangalore.

The tensile properties in addition to being tested at Geological and Metallurgical Laboratories, was also tested at the Indian Institute of Science, Bangalore, to avoid any instrumental variation error.

The S.E.M. studies were carried out at Indian Institute of Science, Bangalore.

Tensile Test:- Five samples of each wire was taken and a fixed measured length of 5mm was the constant span of wire tested.

The wire is held between 2 chucks in the tensometer* under constant strain rate of 3.2mm/minute. The stress strain curve is plotted simultaneously on the recorder. The beam used is 500kg to get higher magnification. The curve obtained is called the "Engineering stress strain curve".

Prior to initiation of the tensile test, the wire is flash welded in a thermocouple bead making machine with plenty of coolant [oil] over the mercury to prevent heating of the wire which may have changed its properties, this is done to get a good grip in the chucks to prevent slipping as the test is carried out.

Surface Topography

One specimen of each wire was evaluated with the aid of the scanning electron microscope (S.E.M)*

The specimens around 1 inch long were mounted on specimen studs. The platform with the mounted specimens were then placed in the ion sputtering machine" and gold dust is coated on the specimens. The specimens once coated completely with goldust is removed from the sputtering machine and is then placed inside the vaccum chamber of the scanning electron microscope. An acclerating voltage of 20kv and a current of 3 amperes were used. The surface was scanned for any irregularities and observed on the screen at 200X, 500X & 1000X mangification. Photographs of the specimen were then taken at 200X magnification.

PHOTOMICROGRAPHS ILLUSTRATING THE SURFACE TOPOGRAPHY (FIG. 1 TO 7)

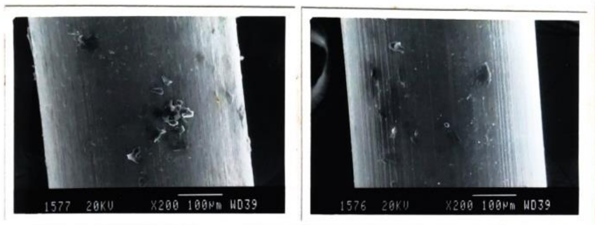

FIG. 1 & 2 - A.J. WILCOCK SPECIAL PLUS AND EXTRA SPECIAL PLUS RESPECTIVELY

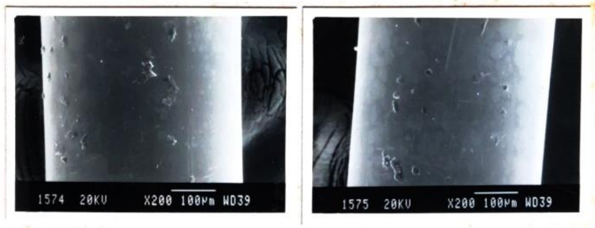

FIG. 3 & 4 - T.P. ORIGINAL WIRE PREMIER AND PREMIER PLUS RESPECTIVELY

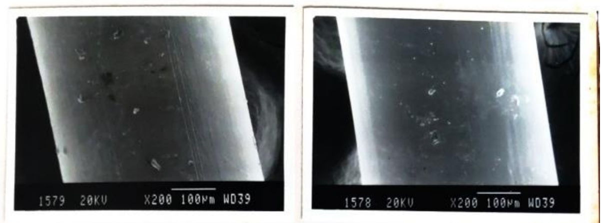

FIG. 5 & 6 - DENTAURUM SUPER SPRING HARD AND SUPER SPECIAL SPRING HARD RESPECTIVELY

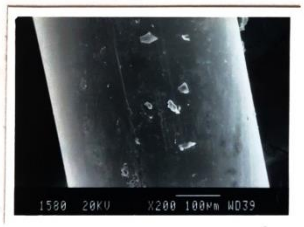

FIG. 7 - 3M/UNITEK UNISIL

PHOTOMICROGRAPHS ILLUSTRATING FRACTURE CHARACTERIZATION (FIG. 8 TO 14)

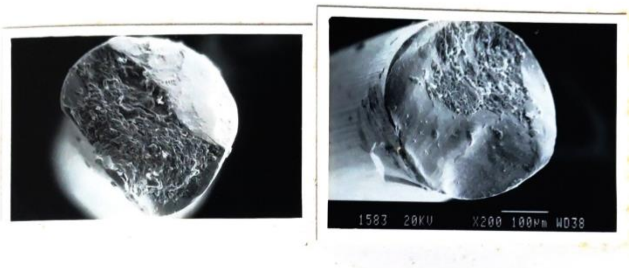

FIG. 8 & 9 - A.J. WILCOCK SPECIAL PLUS AND EXTRA SPECIAL PLUS RESPECTIVELY

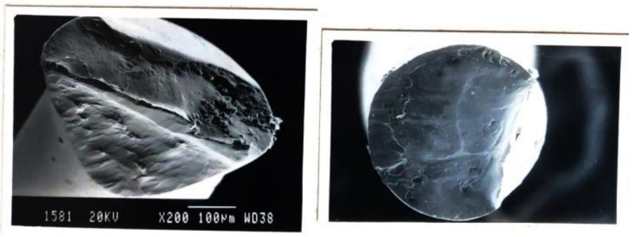

FIG. 10 & 11 - T.P. ORIGINAL WIRE PREMIER AND PREMIER PLUS RESPECTIVELY

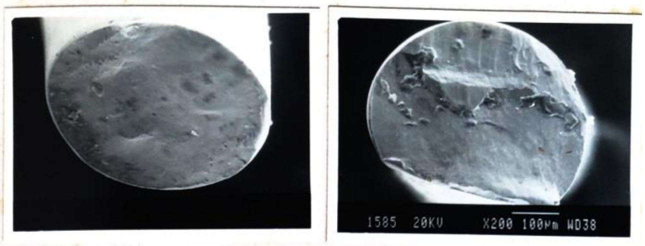

FIG. 12 & 13 - DENTAURUM SUPER SPRING HARD AND SUPER SPECIAL SPRING HARD RESPECTIVELY

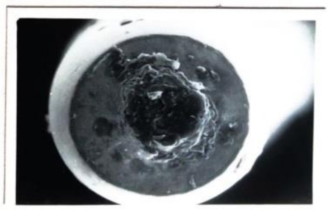

FIG. 14 - 3M/UNITEK UNISIL

Crystalline Structure

The specimens of wire material that had undergone the tensile test were included in this particular study to scan the fractured site. The specimens are mounted and coated with gold dust (electrically conductive adhesive) similar the surface topographics study. The surface was scanned and observed on the screen at 20X, 200X, 500X & 1000X magnifications photographs of the specimens were then taken at 200X magnifications since it gives a representative picture of the quality of the entire wire. The photographs were then qualitatively assessed for any surface defects or inclusions of foreign materials.

RESULTS

Tensile Properties

The ultimate tensile strength and yield strength are calculated from the stress strain graphs for all grades of wires. (Tables 1, 2, 3, 4), (Graph I, IA, III, IIIA)

Analysis of difference between each corresponding grade of wire is done by using the students unpaired 't' test of significance between means.

It is found that ultimate tensile strength and yield strength was highest for Wilcock wires and lowest for Dentaurum's super spring hard. The difference between means is very highly significant. (Tables 5,6,7,8). Tensile properties tested through instrument A and instrument B showed consistent values and difference between means is statistically non significant. (Graph II and IV).

Microhardness

The microhardness values are calculated for all grades of wires. (Table 9) (Graph V).

Analysis of difference between each corresponding grade of wire is done using the students unpaired 't' test of significance between means.

It is found that microhardness values was highest for Wilcock's extra special test followed by special plus and lowest for T.P. Original wire premier plus. The difference between means, is very highly significant. (Table 10).

Summary

The objective of this study was to evaluate and do a meaningful comparison of different types of stainless steel round wires having a mean diameter of 0.016".

The properties evaluated are: a) Tensile properties, b) Micro hardness, c) Surface topography, d) Crystalline structure at the fracture site. From the present study Australian Wilcock wires both Extra Special plus and special plus showed the highest values of strength & hardness under both instrument A & B when compared to the other wires.

Moreover, the scanning electron microscopic study of the fracture site showed that Wilcock wires demonstrated the highest ductility. Thus, it could be confirmed that Wilcock wire is the toughest wire [ESP & regular plus] in the present study.

However, the scanning electron microscopic study of the surface topography showed that T.P. Original wire showed a more superior surface finish with fewer surface defects, when compared to Wilcock wires which showed many surface drawmarks, proving that Wilcock wire would offer more amount of frictional resistance and susceptibility to corrosion than T.P To conclude, the present study has revealed that laboratory tests alone do not seem capable of identifying major short comings of a new wire material. From this study, it appears that a combination of simple mechanical tests & electron microscopic studies, ought to be most relevant. However, to determine the exact properties of the wire, it must be subjected to invivo clinical conditions and then tested for various properties.

Further, due to difficulty in availability of testing equipment & extensive testing procedures, required to be carried out, before the effectiveness of a wire can be determined; search for a simple laboratory method which simulates the intra oral environment, continues as a matter of urgency in order to expose any in built weaknesses in new wire materials.

CONCLUSION

This study proves that the Wilcock wires, because of their high strength and ductility are a better wire in opening deep overbites and aligning arches, for use in stage-I of the differential force light wire technique.

On the other hand, T.P Original wire and to a lesser extent Dentaurum remanium wire with its highly polished surface would offer the least amount of frictional resistance and is ideal for use in stage-II of differential force light wire technique.

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