Effect of pre-stretching of surgical stainless steel wires on their ultimate load bearing strength - a prospective study

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ABSTRACT

Aim: To evaluate the effect of different percentage elongations on the ultimate tensile strength of 24 and 26 gauge stainless steel wires.

Materials and Methods: 5 sets of wires were taken from a single spool of 26 gauge and 24 gauge obtained from a single manufacturer. They were pre-stretched to different percentages of 0%, 2.5%, 5%, 7.5%, 10% and 12.5%. The wires were cut to a standard length of 20 cm each and were subjected to tensile stretching forces at a uniform rate of 20mm/minute in Universal Testing Machine (UTM). The ultimate load was evaluated in each of the wires.

Results: The mean ultimate load for 24 gauge wire was noted to be the highest (62.84± 0.38) in 10% elongation and the least (57.44± 0.32) in 12.5%. Whereas in 26 gauge, mean ultimate load was noted to be highest (62.64 ± 0.16) in 5 % elongation and least (58.39 ± 0.26) in 10% elongation.

Conclusion: We can do pre-stretching of 24 gauge wire upto 10 % for maximum ultimate strength and for 26 gauge upto 5% for maximum ultimate strength.

Keywords: Ultimate Tensile Strength, Universal Testing Machine, Stainless Steel Wire

INTRODUCTION

Mandible fractures being the most common skeletal injuries in humans due to penetrating or blunt trauma[1,2] which includes para-symphysis, body, angle and condylar fractures; with the treatment option of either closed reduction or open reduction internal fixation (ORIF). In both of the treatment options IMF i.e. inter-maxillary fixation with stainless steel wire is required which deliver temporary dental occlusion during preoperative, operative and postoperative phase of treatment.[2,3] The stainless steel wire used in IMF is available in various gauge; 26 gauge and 24 gauge wires are most commonly used in IMF. Usually pre-stretching of stainless steel wire is done to have maximum ultimate strength which prevent breakage of wire during IMF; thus prevent unnecessary injury to clinician, patient and assistant and lessens the gingival penetration of wires due to breakage.[4] So, the study was proposed to evaluate the effect of different percentage elongations on ultimate tensile strength of 2 gauge and 26 gauge stainless steel wires.

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MATERIAL AND METHOD

A prospective study was planned using Universal Testing Machine (UTM-Asian Test Equipment) to evaluate effect of pre-stretching of surgical stainless steel wires on their ultimate load bearing strength. 5 sets of wires was taken from a single spool of 26 gauge and 24 gauge obtained from a single manufacturer. They were pre-stretched to different percentages of 0%, 2.5%, 5%, 7.5%, 10% and 12.5%. The wires were cut to a standard length of 20 cm each and were subjected to tensile stretching forces at a uniform rate of 20mm/minute in Universal Testing Machine (UTM) as shown in Fig. 1 and 2. The ultimate load was evaluated in each of the wires. Independent t-test was applied to evaluate the difference of mean between different gauge wires. Statistical analysis of the data was done by using SPSS IBM Statistics version 20.

RESULT

The result of this prospective study showed that the mean ultimate load for 24 gauge wire was noted to be the highest (62.84±0.38) in 10% elongation and the least (57.44±0.32) in 12.5%. Whereas in 26 gauge, mean ultimate load was noted to be highest (62.64±0.16) in 5% elongation and least (58.39 ±0.26) in 10% elongation. Graph 1 and 2 shows the graphical representation of 24 gauge wire mean ultimate load in Newton (N) with different percentage of stretching.

Fig. 1: Shows Universal Testing Machine (UTM) of Asian Equipment

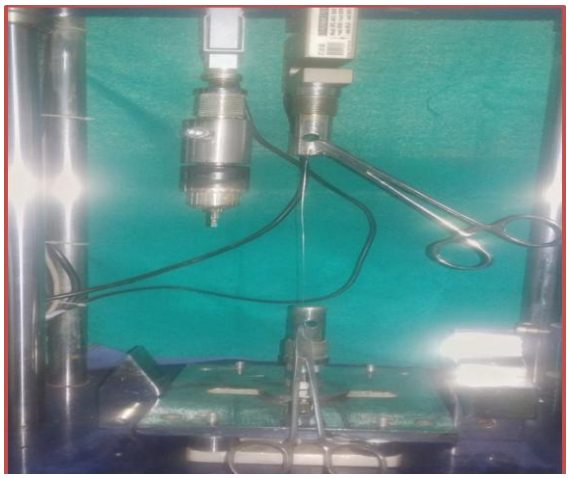
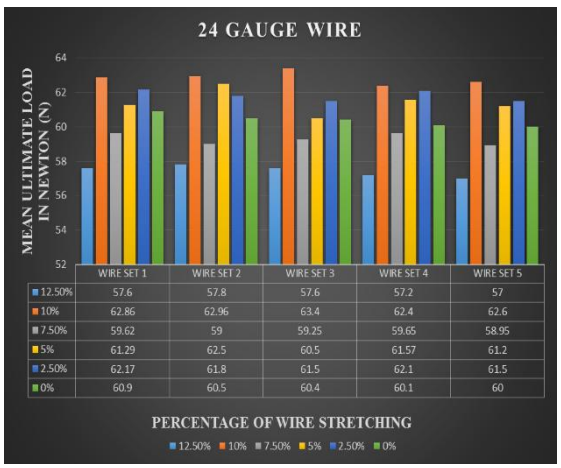
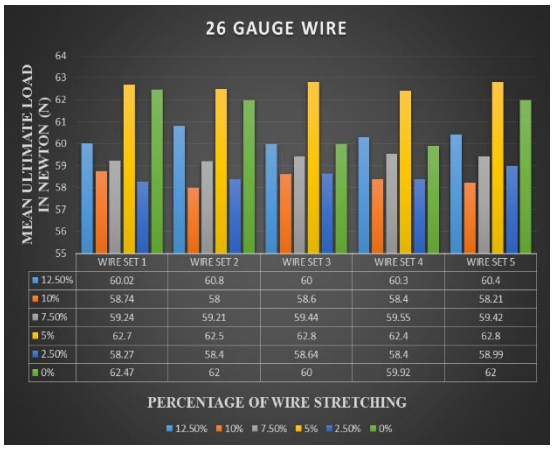


Fig. 2: Shows stretching of stainless steel wire under tensile stretching forces at a uniform rate of 20mm/minute in Universal Testing Machine (UTM)



	WIRE SET 1	WIRE SET 2	WIRE SET 3	WIRE SET 4	WIRE SET 5
12.50%	57.6	57.8	57.6	57.2	57
10%	62.86	62.96	63.4	62.4	62.6
7.50%	59.62	59	59.25	59.65	58.95
5%	61.29	62.5	60.5	61.57	61.2
2.50%	62.17	61.8	61.5	62.1	61.5
0%	60.9	60.5	60.4	60.1	60

Graph 1: Shows the graphical representation of 24 gauge wire mean ultimate load in Newton (N) with different percentage of stretching



	WIRE SET 1	WIRE SET 2	WIRE SET 3	WIRE SET 4	WIRE SET 5
12.50%	60.02	60.8	60	60.3	60.4
10%	58.74	58	58.6	58.4	58.21
7.50%	59.24	59.21	59.44	59.55	59.42
5%	62.7	62.5	62.8	62.4	62.8
2.50%	58.27	58.4	58.64	58.4	58.99
0%	62.47	62	60	59.92	62

Graph 2: Shows the graphical representation of 26 gauge wire mean ultimate load in Newton (N) with different percentage of stretching

DISCUSSION

For decades, use of stainless-steel wire has been the foundation for management of facial trauma and reconstructive surgery by oral and maxillofacial surgeons. It is of interest that one of the materials most frequently used by oral and maxillofacial surgeons has received so little attention in the literature. Lemmons and Alling in 1977 provided a detailed discussion of the metallurgic properties of stainless- steel wires and the rationale for and against pre- stretching;[2] however, their article was a literature review and provided no definite conclusions. In 1989, Colm and Farish provided an excellent dissertation on the physical properties of 25 gauge stainless-steel wire and the changes that occur with pre-stretching.[3] This study was based on a sample of six prestretched wires and three controls, without a known degree of prestretching force. The results of the study provided a description of the changes in physical properties for industrial application but not for the clinical setting.

The difference in physical properties between stretched and unstretched wire occurs because as the wire is stretched its ordered crystalline pattern is disturbed. Slippage along the orderly planes that were in the initial crystalline pattern of the wire becomes more difficult once it has been stretched because adjacent portions of the structure are dis- located by the stretching and tend to resist further deformation.[4] The stretching of the wire is a form of cold-working or strain-hardening which decreases the elasticity and deformation of the material. The process of strain-hardening increases the Yield Strength and Ultimate tensile strength of a material as the cold-working is increased. The stretched wire demonstrates this increase in Yield Strength and Ultimate tensile strength with a concurrent decrease in elasticity. This cold working will result in an increased strength and minimal deformation when the wire is used for osteosynthesis, arch bar placement, or maxillomandibular fixation. Loosening during the period of use is reduced when the wire is prestretched

and the sequelae of inadequate immobilization, such as nonunion, pain, and infection, are minimized.[5]

Clinical concerns about stainless steel wire are breakage during application, loosening or breakage during fixation and the sharp ends can lead to wire-stick injuries with the potential risk of virus-associated diseases and infections such as hepatitis B (HBV), hepatitis C (HCV), and human immunodeficiency viruses (HIV).[6] Thomas et al. reported that anti-HCV was found in 2.0% of oral surgeons, and serological markers of HBV infection in21.2%.[7]

According to our study the mean ultimate load for 24 gauge wire was noted to be the highest (62.84±0.38) in 10% elongation and the least (57.44±0.32) in 12.5%. Whereas in 26 gauge, mean ultimate load was noted to be highest (62.64±0.16) in 5 % elongation and least (58.39±0.26) in 10% elongation. Therefore if we pre-stretched 24 gauge wire to 10% and 26 gauge wire to 5% then this will prevents wire breakage, loosening and wire stick injuries.

CONCLUSION

The use of wires in maxillofacial surgery is simple, quick, economical, and minimally invasive.[8] Healthcare professionals in the field of oral and maxillofacial surgery have a higher than normal risk of wire-stick injuries, but this could be reduced if wires is stretched appropriately so that it can have optimum ultimate tensile strength which prevents wire breakage and thus preventing wire-stick injuries. We suggest a pre-stretching of 24 gauge wire upto 10% for maximum ultimate strength and for 26 gauge upto 5% for maximum ultimate strength.

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