Extended Abstract with Poster

Surgical Techniques and Their Reliability

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Abstract

This paper investigates the reliability of two suturing techniques, which anchor surgical drains to the human skin/. Two suturing techniques are explored, namely the Roman Sandal (RS) and the modified Roman Sandal (MRS) suturing techniques. It was hypothesized that the MRS is more reliable than the RS suturing technique.

Introduction

Surgical drains are used to extract unwanted fluid from the organs of the body. The surgeon places them into the patient's body and secures them to an underlying organ such as skin via surgical sutures. Based on the oscillatory breathing motion of the patient's skin, the sutures loosen up and their grip on the drains weakens. The drain can then be displaced from its intended position. A secondary surgery is required to place it back into its intended location. The focus of this research is to investigate and compare two different suturing techniques that are used to anchor the drains.

Methods

The mechanical reliability of the RS and the MRS suturing techniques are tested via the use of the Instron tensile testing machine (Fig. 1). The loosening of the suture knots in a natural setting initiates after long periods of respiratory cycling of a patient's skin or drain and resembles a fatigue testing.

To simulate such the oscillatory behavior a custom-made fixture was designed and constructed (Fig. 1), which was attached to the stationary arm of the IM. The stationary sponge mimics the skin of a patient through which the drain runs through and oscillates.

RS suturing technique

Fig. 2 shows one of the RS test trials that were experimented with in the laboratory. The RS suturing technique involves two knot units. See Fig. 3. Each knot unit consists of 4 surgeon's knots.

MRS suturing technique

Fig. 4 shows one of the MRS test trials that were experimented with in the laboratory. The MRS suturing technique involves three knot units. See Fig. 5. Each knot unit consists of 4 surgeon's knots.

Failure Criteria

Suture unit displacement

The suture unit displacement or slippage is defined as the distance of dislodgment of the LB of the suturing from a previously specified datum, namely the black marking shown in Figs. 6 and 7. The suture unit displacement determines the deviation of the LB, involved in either the RS or the MRS experimental trial from the datum. The location of marking/datum is indicated by the white dashed lines in Figs. 2 and 4.

Suture unit collapse

The suture unit collapse is defined by the difference between the initial and the final distance between the LB and the second knot unit in the case of the RS suturing technique. With regards to the MRS, the collapse is defined by the difference between the final and the initial distance between the LB and the UB. See Figs. 6 and 7. Note that the collapse is measured once the knot unit has slipped 5.0 mm or more.

Number of oscillations needed to fail

The number of oscillations needed to fail was the third failure criterion tracked during all the experimental settings. For each experimental run involving both suturing techniques, the number of oscillations needed to reach the 5.0 mm mark was closely documented.

Results

RS Suture units

A total of 42 experimental runs were conducted for the RS suture technique. This number exceeds the necessary 40 number of trials required for obtaining statistically viable results. 36 RS trials failed during the first oscillation. Six of them failed during the second oscillation. The obtained results regarding the RS suture units were therefore sorted in two different categories. Graphs 1 & 2 show the results for the RS.

MRS Suture units

A total of 5 experimental runs were conducted. This is due to fact that each run needed more than 100 oscillations to result in the failure of the MRS suture units. This positive jump in the effectiveness of the MRS suture unit performance was so overwhelming that five trials were sufficient to contrast the difference between the reliability of the RS and MRS suturing techniques. Graphs 3 to 8 show these the results for the MRS.

Conclusion

Displacement of surgical drains from their intended location of attachment can lead to postoperative complications. After such displacements, the patient usually undergoes a secondary operation so that a new drain can be placed at the correct location. The usual drain anchoring mechanisms involve the use of a common suturing technique, namely the RS suturing technique. This research mechanically investigated the RS and the MRS to determine the reliability of these suturing techniques.

Under similar mechanical conditions, on average, the RS suture units failed only after one oscillation. However, the MRS suture units failed after more than 100 oscillations. The average RS suture unit slippage along the drain was 9.0 mm, whereas the average MRS suture unit slippage along the drain was 5.0 mm.

Based on the above findings the hypothesis of this research has been verified. The hypothesis was to prove that the MRS suturing technique is a more reliable and effective anchoring technique compared to the RS suturing technique.

References

1. Dini, G.M., De Castillo, H.T., Ferreira, L.M., 2003, “A Simple Technique to Ensure Drain Fixation.” Journal of Plastic Reconstructive Surgery, Vol. 112(3), pp. 923-924.
2. O'Flynn, P., and Akhtar, S., 1999, “Effective securing of a drain.” Annals of the Royal College of Surgeons of England, Vol. 81, pp. 418–419.
3. Hormbrey, E., Pandya, A., and Humzah, D., 2000, “Drain fixation made foolproof.” Annals of the Royal College of Surgeons of England, Vol. 82, p. 219.

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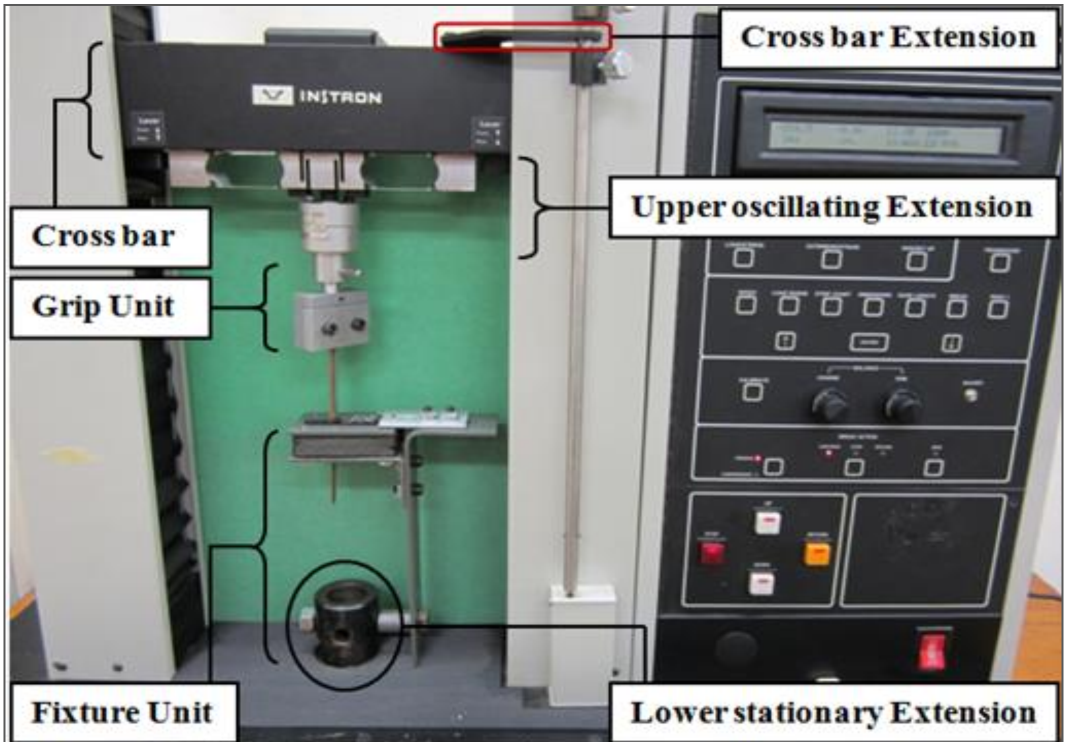


Figure 1: Instron tensile testing machine & the Fixture/Grip system.

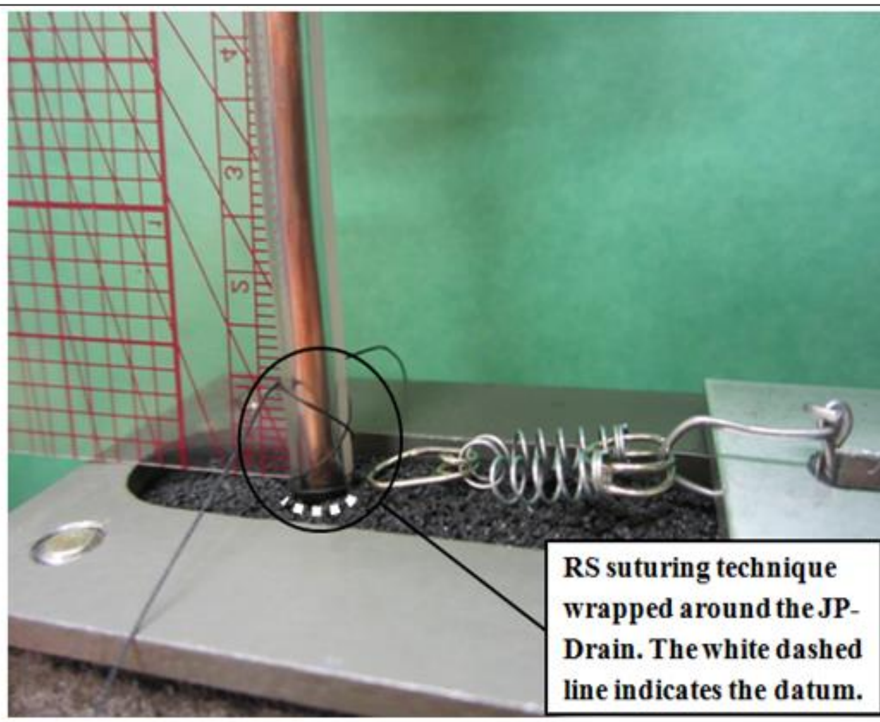


Figure 2: RS suturing technique with 1.0 cm initial separation between the lower base and the second knot unit used in the research setting.

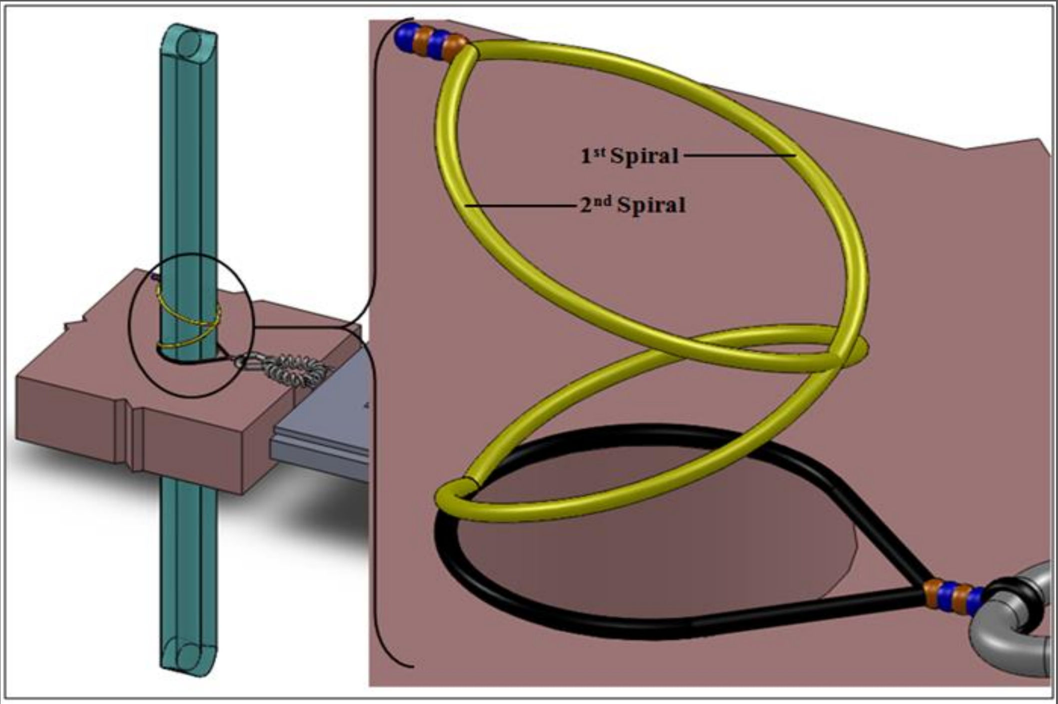


Figure 3: Isometric View. The RS suturing technique. On the left the RS is employed around the JP-Drain, which passes through the skin. On the right, a zoomed view of the RS suture technique. Note that the black segment is considered as the lower base (LB).

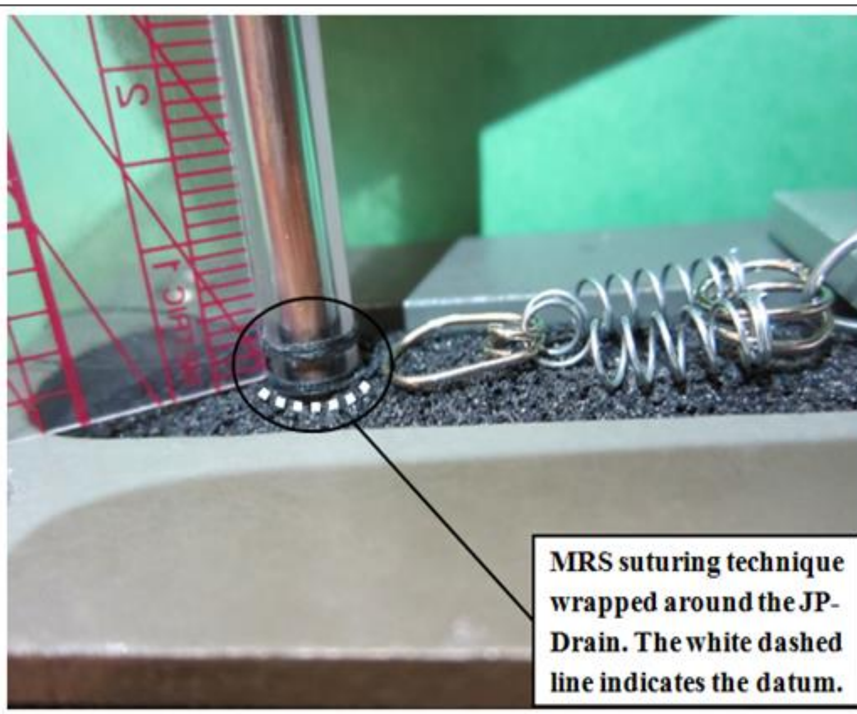


Figure 4: MRS suturing technique with 2.5 mm initial separation between the lower base and the upper based used in the research setting.

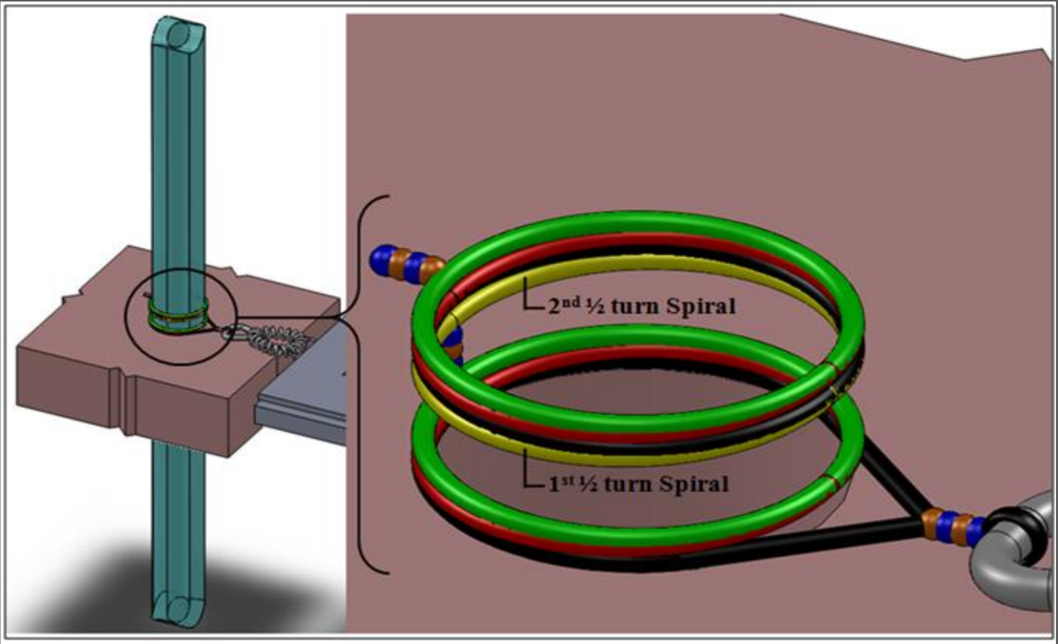


Figure 5: Isometric View. The MRS suturing technique. On the left the MRS is employed around the JP-Drain, which passes through the skin. On the right, a zoomed view of the MRS suture technique, the three knot units as well as the mode of attachment to the moveable ring. Note that the lower black segment is considered as the lower base (LB) and the upper black segment is considered as the upper base (UB).

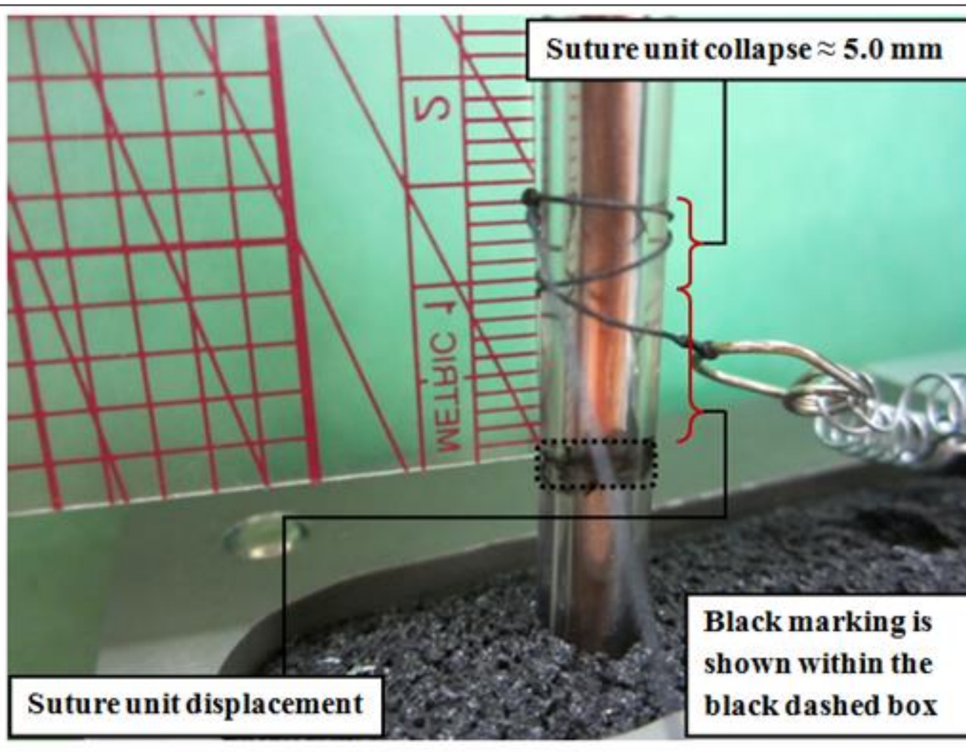


Figure 6: The RS suturing technique reaching a suture unit displacement of 9.0 mm.

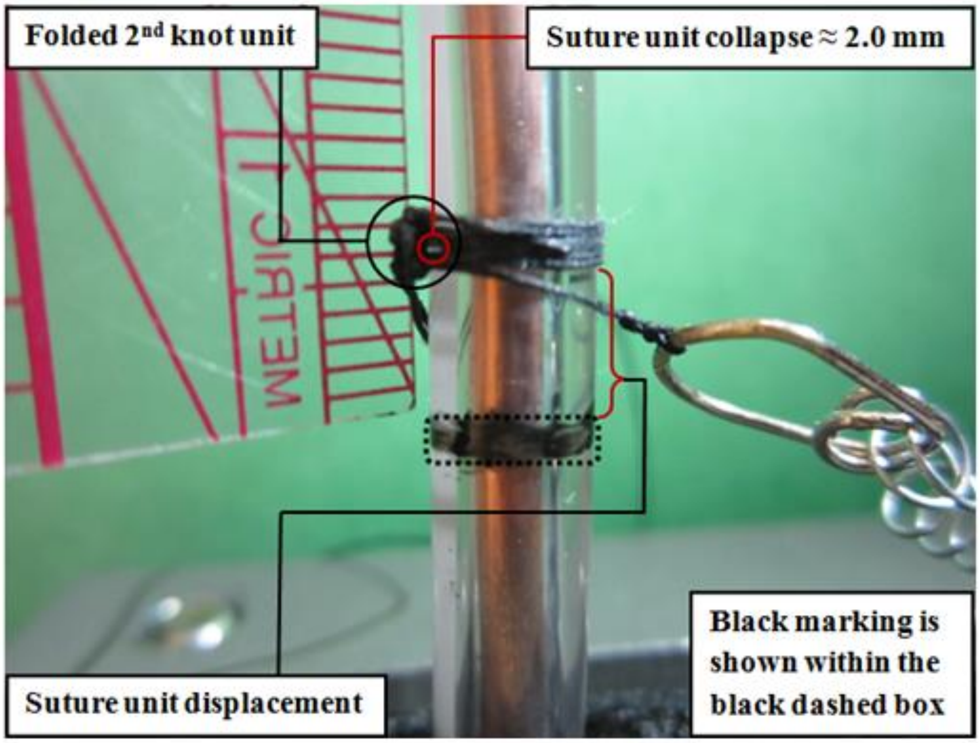
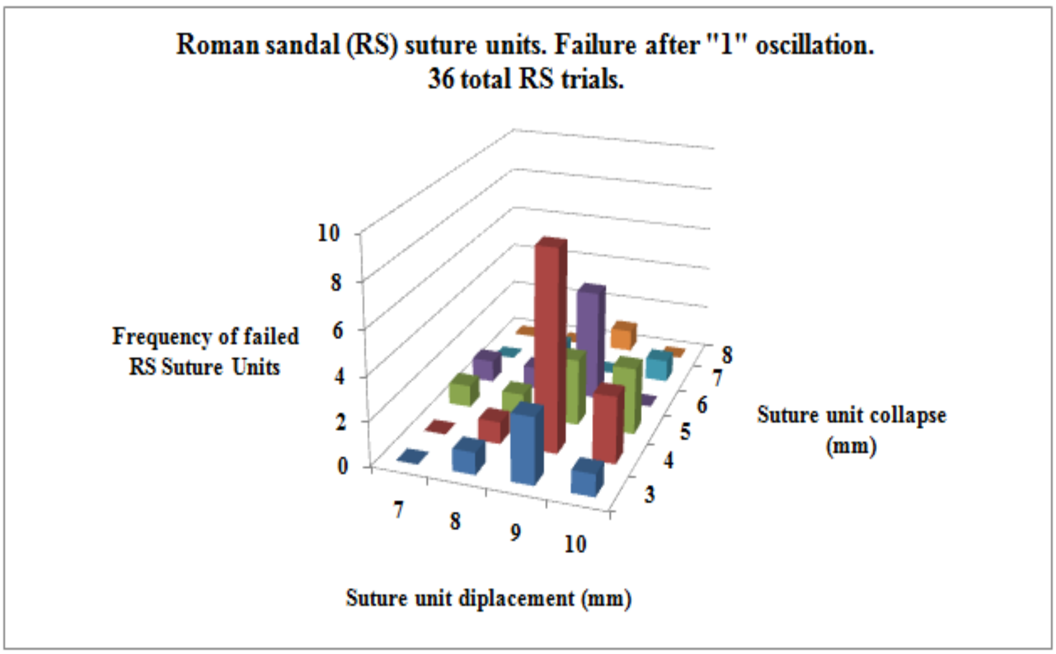
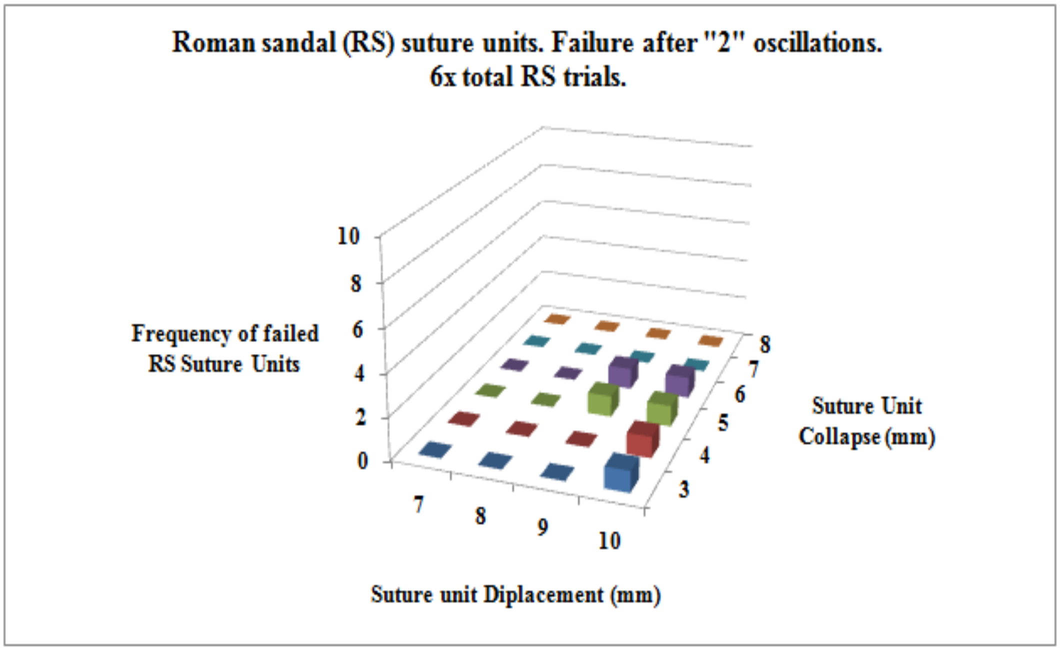


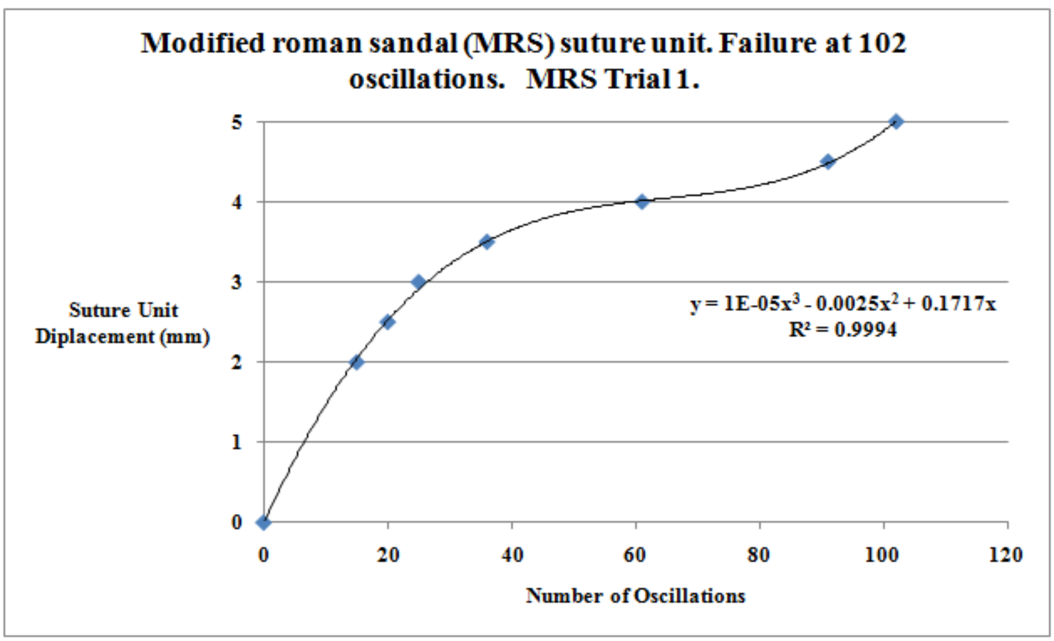
Figure 7: The MRS suturing technique reaching a suture unit displacement of 5.0 mm.



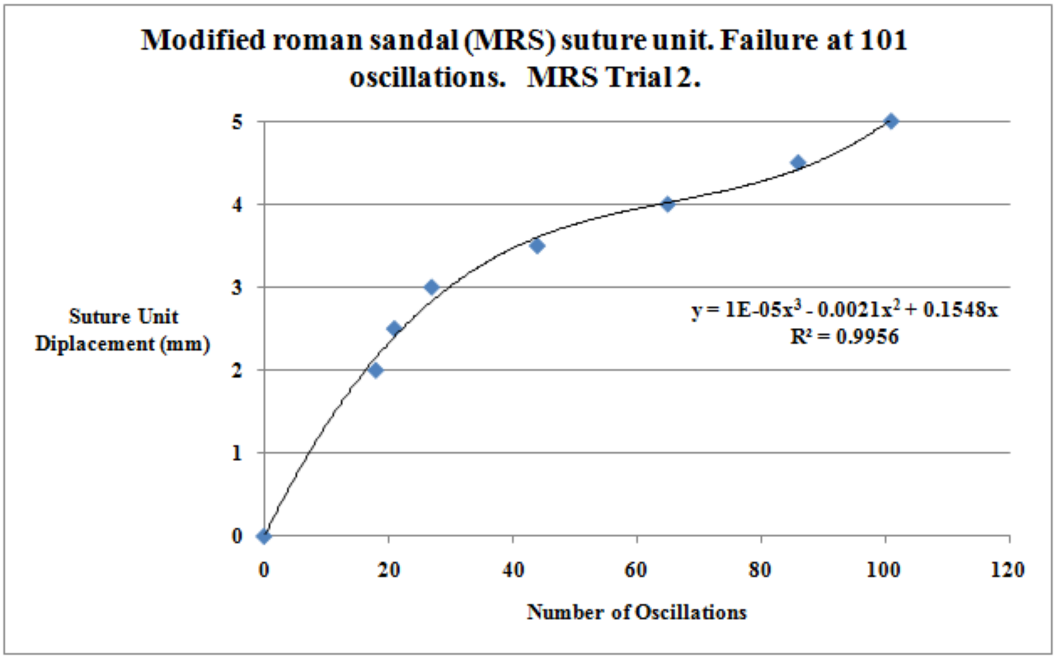
Graph 1: 36 total of RS experimental trials all failed after "1" oscillation.



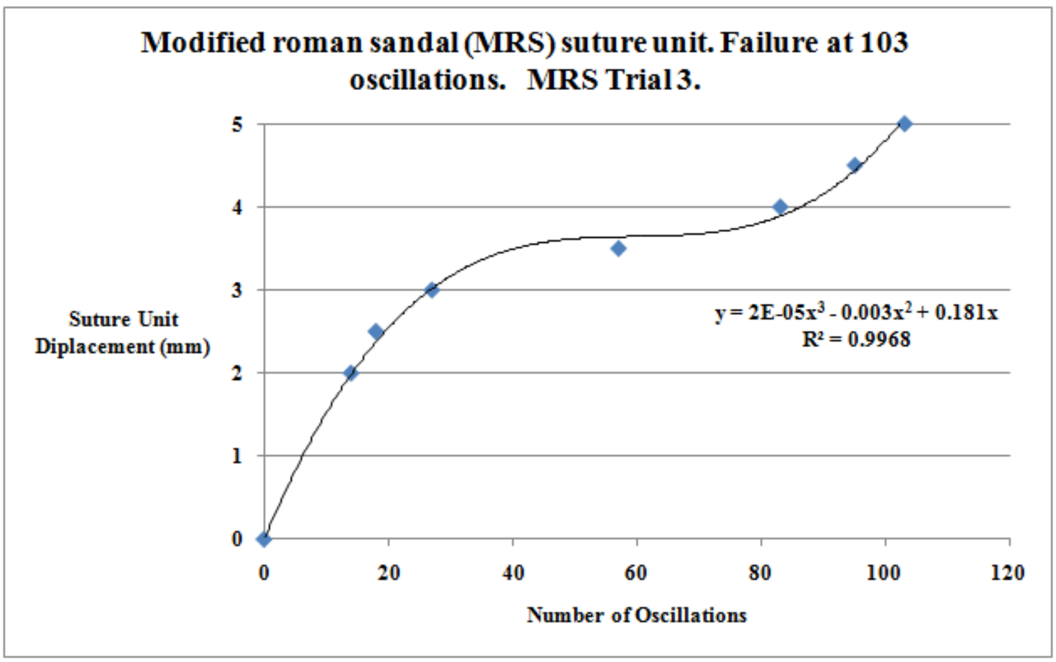
Graph 2: 6 RS experimental trials all failed after “2” oscillations.



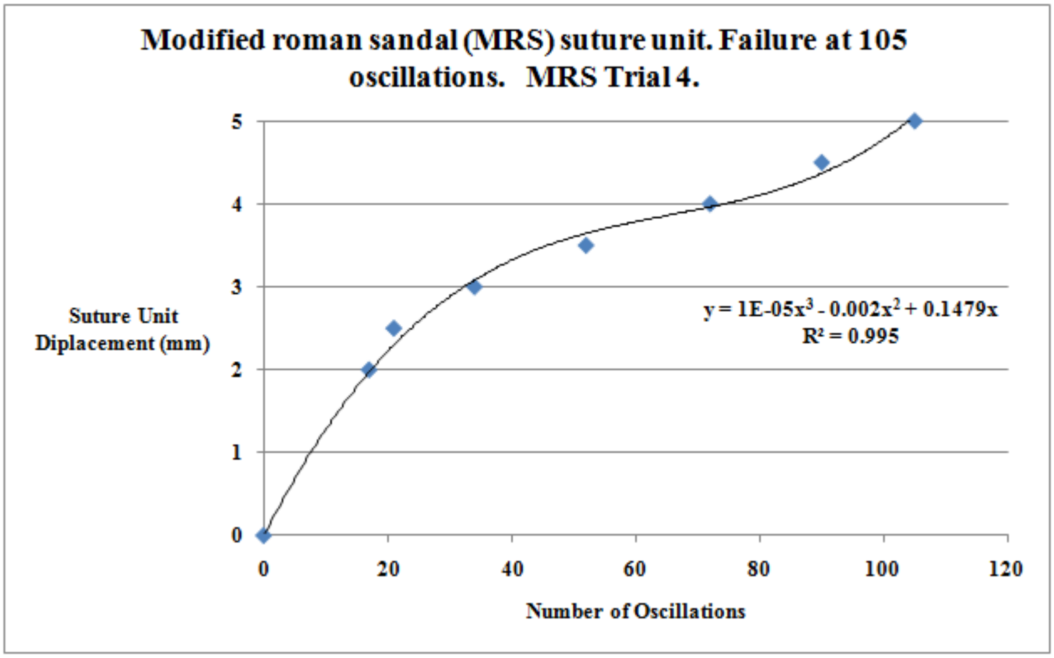
Graph 3: first MRS Experimental Trial. Failure occurred after 102 oscillations.



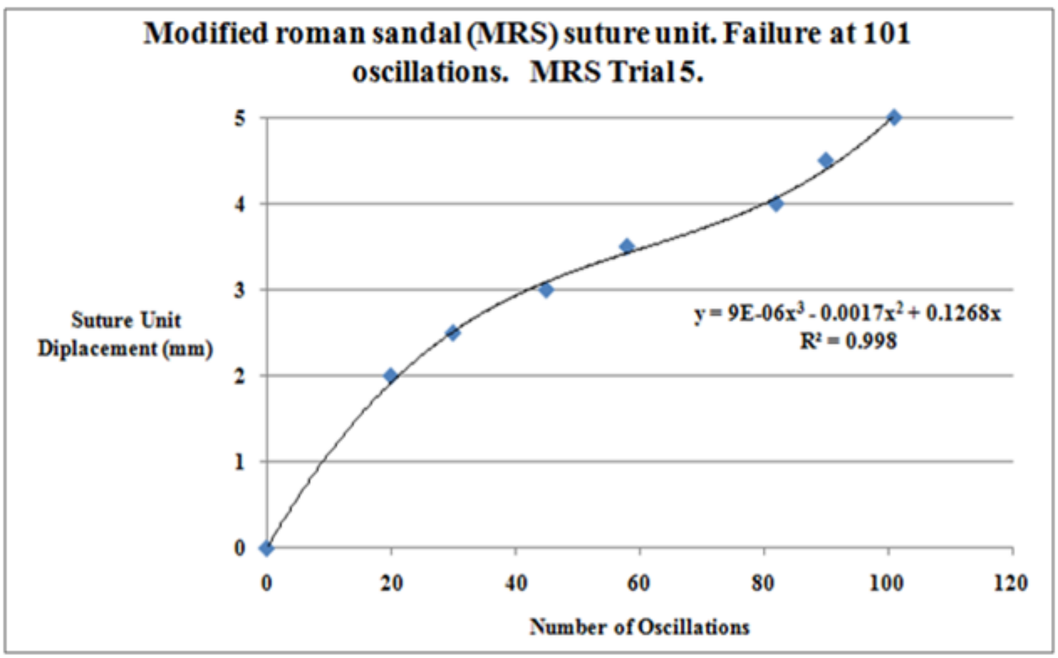
Graph 4: second MRS Experimental Trial. Failure occurred after 101 oscillations.



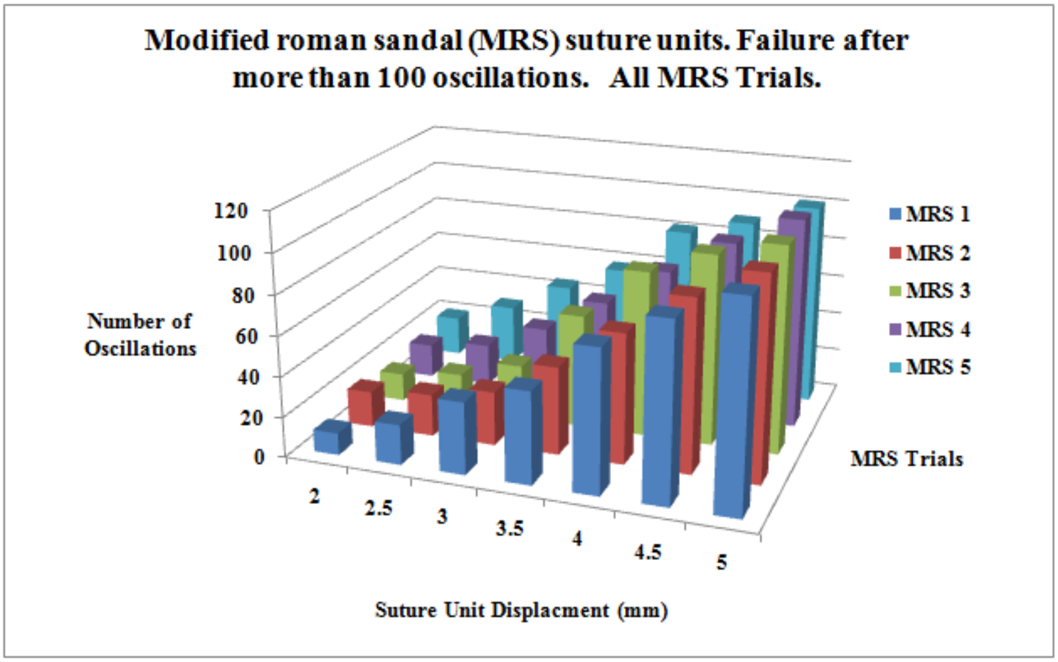
Graph 5: 3rd MRS Experimental Trial. Failure occurred after 103 oscillations.



Graph 6: 4th MRS Experimental Trial. Failure occurred after 105 oscillations.



Graph 7: 5th MRS Experimental Trial. Failure occurred after 101 oscillations.



Graph 8: All MRS Experimental Trials.