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The ''Do It Yourself'' Tendon Repair Model: the Use of Silicone for Basic Tendon Surgery Training

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Abstract

In order to facilitate the simulation of tendon repair, especially nowadays when a trainee has limited working hours, various non-living tendon repair training models have been described in literature. One of these ingenious models consists of silicone injected into a cast such as a drinking straw, but despite its simplicity, there is no information on how various variables such as cast length and diameter or temperature and air exposure influence the production process.

Therefore we have set out to research how various factors influence the manufacturing process of a silicone tendon repair model in order to easily reproduce and use it for personal training.

Keywords: tendon repair, simulation, surgical training, silicone model.

Rezumat

Pentru a facilita dobândirea tehnicilor de bază în sutura tendinoasă numeroase modele artificiale de simulare au fost descrise în literatura medicală pâna în prezent. Unul dintre aceste modele constă în creearea unui „pseudo-tendon'' prin introducerea de silicon uzual într-o matriță cilindrică, care este lăsat la uscare și ulterior este extras și utilizat pentru practicarea tenorafiei. Deși acest model pare intuitiv și simplu de utilizat, nu este clar cum diferite variabile precum lungimea și diametrul matriței, temperatura ambientală sau expunerea la aer influențează procesul de uscare. Astfel ne-am propus să investigăm cum factorii menționați mai sus afectează obținerea unui „pseudo-tendon'' pentru simularea tenorafiei astfel încât să poată fi implementat cu ușurință în practica personală a fiecărui aspirant în domeniul tehnicilor de sutură tendinoasă.

Cuvinte cheie: reparare tendinoasă, simulare, pregătire chirurgicală, model de silicon.

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INTRODUCTION

In order to succeed in tendon repair, the hand surgeon must have a thorough clinical judgment related to when and how to repair an injured tendon[1] as well as the necessary technical skills regarding the surgical approach and the optimal placement of core and peripheral tendon sutures that will ensure the necessary strength for early rehabilitation protocols[2,3].

In an effort to facilitate the simulation of tendon repair, especially nowadays when a trainee has limited working hours [4], various non-living tendon repair simulators have been described in literature[5-13] and they are categorized as inanimate biological tendon repair models such as swine or sheep limbs[6-7] or synthetic tendon repair models such as dental rolls, synthetic bait worm, drinking straw, liquorice, silicone sealant and urinary catheter[8-13], the latter group providing the advantage of a dry, non-biological material[14].

By injecting silicone sealant into a mold or cast such as a drinking straw and leaving it to harden for two weeks, a low-fidelity tendon repair simulator was obtained, as described by Wijeratna et al.[12].

However, information on cast properties such as length and diameter or environmental factors such as temperature or air exposure were not detailed in the original report.

We have decided to further explore, test and refine Wijeratna's method in order to get a comprehensive understanding about how this method can be easily reproduced and used for the purpose of personal training.

MATERIALS AND METHODS

An artificial tendon repair model was manufactured using white or colorless commercially available silicone sealant that was either injected into a mold (closed) or was exposed to air (open technique). The closed technique required a total of 40 drinking straws of 7.5 cm and 15 cm length, each one having a 5 mm and 7 mm diameter. For the open technique we used a grooved semicircular plastic spacer that was filled with silicone along its length. The silicone sealant was injected via a pistol pumping device and left to dry in a confined well-ventilated space at room temperature which was daily recorded. The immobility of the silicone column in the drinking straw while applying pressure suggested the proper time for extraction via an incision.

RESULTS

At a mean temperature of 24.3 degrees Celsius it took between 7 to 13 days for the silicone to be fit for extraction by using the closed technique and 1 day by using the open technique.

The diameter of the drinking straw was the factor that contributed the most to the time needed for the silicone to harden (up to 7 days for the 5 mm drinking straw and up to 13 days for the 7 mm drinking straw).

The closed technique offered a smooth, proportionate silicone rod while the open technique produced a rough, uneven and disproportionate silicone rod.

The silicone "tendons" were fixed on a wooden board with pins or were taped on the working table for the practice of basic tendon repair.

DISCUSSION

In their article Wijeratna et al. presented a novel, low cost model for tendon repair that was manufactured out of commercial silicone sealant that was injected into a drinking straw and further left to curate for two weeks until its due time as a tendon repair simulator[12]. Despite its simplicity the authors have not specified how variables such as temperature, diameter and length of the cast may influence the manufacturing process or if the process can be replicated without a cast.

In our experiment we have observed that the manufacturing method determines the quality of the silicone rod related to its shape and texture. A good cast leads to good results, while the absence of a cast leads to unfavorable results. Air exposure facilitates silicone's drying in one day at the expense of surface and size quality while for a cast it may take up to 13 days depending on the cast's diameter but with the maintenance of a tendon-like aspect.

Basic procedures such as minimal debridement of tendon ends followed by core and peripheral suture placement (Figure 2) or partially suturing tendons may be easily practiced (Figure 3). A transparent silicone rod may help to comprehend the grasping and locking principle or practice various sutures techniques (Figure 4), before advancing to a white colored silicone model (Figure 2 and 3).

The adoption of simulators in surgical training has been shown to decrease operative times, complication rates and improve patient outcomes[15], as they help develop psycho-motor, technical and decision making

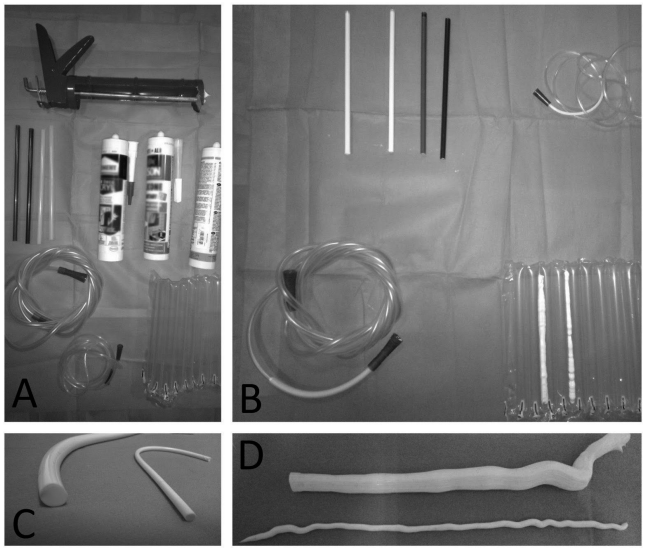

Figure 1. A. Materials that may be used for manufacturing the silicone tendon repair model B. Tubular casts that may be used for the closed technique C. The outcome after using tubular casts D. The outcome after using the open technique.

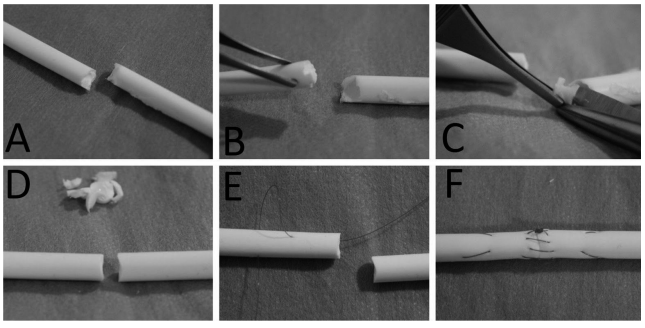

Figure 2. A and B. Lacerated ends of a white-colored silicone model. C. Trimming the lacerated ends. D. The result after trimming. E. Performing a core suture (demonstration of grasping). F. The final aspect after epitendinous suture. The sutures were not tighten for the purpose of visibility.

skills[16]. As Sirisena et al. showed, silicone tendon rods provide a good tool for perfecting the tendon repair before moving on to more realistic scenarios[17]. Due to its elastic properties, the silicone tendon repair simulator remains a low fidelity model, being suitable for "dry practice" before moving on to animal tendons, with more resemblance to human tendons[6,7].

However, it must be stated that this simulator can be easily self-manufactured giving the accessibility of the materials and used for practice in a time frame less than 14 days with a cost of approximately 6.20 Euro for 40 straws (0.15 Euro/model), undoubtedly less expensive than the medical grade silicone rod[12].

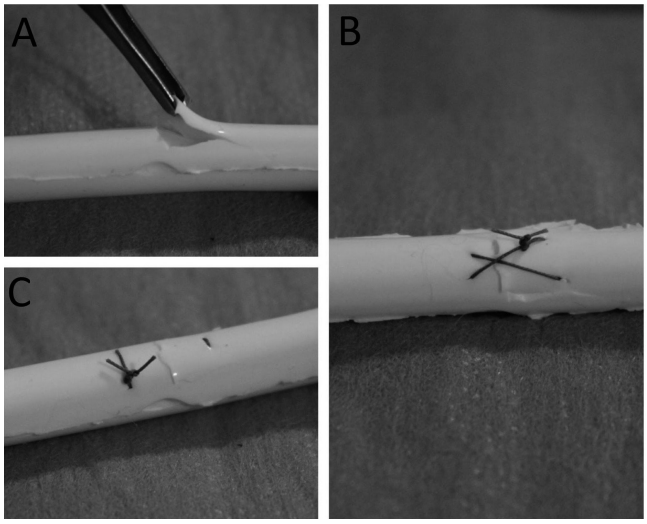

Figure 3. A. Partial laceration of a white-colored silicone tendon. B and C. Different tendon repair techniques. The sutures were not tighten for the purpose of visibility.

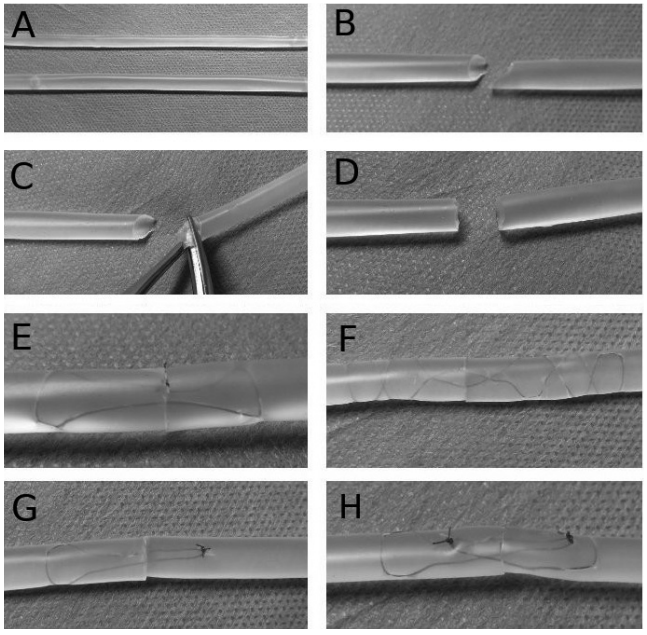

Figure 3. A. Two transparent silicon rods prepared for tendon repair 4B. Uneven stumps C. Trimming of the uneven stumps D. Even stumps E-H: Different core sutures techniques (demonstration of grasping). The sutures were not tighten for the purpose of visibility.

CONCLUSION

The "do it yourself" silicone tendon serves as an excellent initiation tool in tendon repair surgery having the advantage of being non-biological, home training friendly, accessible, low cost and easy-to-reproduce when the right parameters are taken in consideration.

Compliance with ethics requirements: The authors declare no conflict of interest regarding this article. The authors declare that all the procedures and experiments of this study respect the ethical standards in the Helsinki Declaration of 1975, as revised in 2008(5), as well as the national law. Informed consent was obtained from all the patients included in the study.

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