Effects of myrrh on the strength of suture materials: an *in vitro* study

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The present *in vitro* study sought to determine the effects of myrrh-containing solutions on common suture materials used in periodontal surgery. Three commonly used suture materials (silk, polyglactin 910, polytetrafluoroethylene) were immersed in four thermostatically controlled experimental media to simulate daily oral rinsing activity, namely —artificial saliva, normal saline solution with 0.2% *Commiphora* myrrh, full-concentration (100%) *Commiphora* myrrh oil, and a myrrh-containing commercial mouthwash. Tensile strength was measured at the end of each day using an Instron tensile testing machine. Silk sutures were susceptible to tensile strength loss when exposed to 0.2% myrrh solution once daily for 5 days. Myrrh-containing commercial mouthwash had no effect on tensile strength, but all three suture materials lost tensile strength when exposed to 100% myrrh oil. For patients that routinely use myrrh mouthwashes postoperatively, findings of this study suggested that silk sutures might not be the optimal material choice.

Keywords: Myrrh, Suture materials, Tensile strength, Wound healing

INTRODUCTION

A two-pronged approach of using the appropriate suturing technique and suture material plays a critical role in avoiding wound failures, and is key to proper postoperative tissue positioning and adaptation¹⁻⁵. Sutures may degrade and lose their desirable material properties due to extended exposure in hostile environments, such as the stomach which is highly acidic⁶. The oral cavity is an environment with significant variations in both temperature and pH conditions. Such fluctuations are caused by the ingestion of various foods and drinks, as well as the use of oral healthcare products such as toothpastes and mouthwashes. In the oral cavity, different suture materials not only elicit different oral soft tissue responses⁷⁻¹², they also exhibit different behaviors^{8,11,13,14}. *In vitro* studies have examined the material properties of suture materials used in the oral cavity, and a commonly investigated property is their tensile strength^{6,15,16}.

Among the numerous available absorbable and non-absorbable suture materials, silk, polyglactin 910 (PLG), and polytetrafluoroethylene (PTFE) are commonly used in oral and periodontal procedures. Silk is the most commonly used natural suture material, due to its superior handling characteristics¹⁴. PLG is also a commonly used synthetic suture material because it is absorbable¹⁷. It is made from 90% glycolide

and 10% L-lactide, and coated with calcium stearate and a copolymer of lactic acid and glycolic acid. PTFE suture is a polymer of carbon chain with fluoride atoms surrounding it, and it has been largely used in orthopedic and vascular surgeries¹⁸. PTFE is a biologically and chemically inert, biocompatible, and autoclavable synthetic suture material^{19,20}. It does not adhere to tissue and is therefore easily removed.

More than 60% of the global population uses herbal medicines as alternative remedies²¹. Some healthcare professionals may even prefer to use herbal medicines rather than synthetic drugs²². Myrrh is an aromatic resinous exudate obtained mainly from trees of certain *Commiphora* species of the Burseraceae family²³. Evidence suggests that myrrh can be used to treat ulcers, fasciolopsis, respiratory catarrh, furunculosis, and diabetes²⁴⁻²⁹. A tincture of myrrh in alcohol is typically used as an oral astringent and mouthwash, especially for treating painful throat infections³⁰. Traditionally, myrrh was used to treat sore throats and cough, burns, external wounds, and even joint inflammation and tendonitis³¹. Minimum inhibitory concentrations of myrrh have been reported to inhibit common bacterial and fungal pathogens, such as *Escherichia coli*, *Staphylococcus aureus*, *Candida albicans*, and *Pseudomonas aeruginosa*³². Studies have also explored the anticancer and pain-relieving potentials of myrrh resin^{33,34}.

Evidence suggests that toothpastes and mouthwashes which contain myrrh are effective in

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preventing and treating gingival inflammation^{35,36}. In a recent animal study by Al-Mobeeriek³⁰, a dilute myrrh suspension was found to promote the healing and repair of damaged oral tissues. The same study reported possible harmful effects of myrrh when used in excess or over long periods due to either overdosing or inherent adverse reactions to myrrh. Relatively few studies have addressed the potential adverse effects and toxicity of myrrh³⁷⁻³⁹.

On the one hand, sutures are routinely used in periodontal and oral surgeries. On the other hand, myrrh-containing mouthwashes are routinely used during the postoperative period. However, the potential effects of myrrh in myrrh-containing mouthwashes on suture materials have not been investigated. Therefore, the purpose of the present *in vitro* study was to determine the effects of different myrrh solutions on the tensile strength of the three aforementioned suture materials commonly used in periodontal surgical procedures.

MATERIALS AND METHODS

Study design

Three different suture materials were exposed to different media (1 control, 3 test) to simulate possible short-term intraoral exposure to different oral rinses. In summary, suture materials were immersed in artificial saliva and after 24–120 h, test samples were exposed for 1 min to the test media and then measured for tensile strength. The 1-min exposure to the respective test media followed by tensile strength measurement was repeated every 24 h up to 120 h.

Study materials

Tested suture materials were obtained from commercially available, unexpired, sterilized packets. They were namely —4-0 silk (Mersilk™, Ethicon Inc., Somerville, NJ, USA), 5-0 PLG (Vicryl™, Ethicon), and CV-4 PTFE (Gore-Tex® Suture, WL Gore & Associates, Inc., Flagstaff, AZ, USA).

Four thermostatically controlled experimental media were used for suture exposure: (1) Control group (CG)—artificial saliva; (2) Test group-1 (TG-1)—Normal saline solution with 0.2% *Commiphora* myrrh (finely powdered myrrh obtained from a traditional market and diluted in 0.9% sodium chloride)³⁰; (3) Test group-2 (TG-2)—Full-concentration (100%) *Commiphora* myrrh oil; and (4) Test group-3 (TG-3)—Parodontax® mouthwash (which contained caraway oil, chamomile, clove oil, echinacea purpurea, menthol, mint oil, myrrh, peppermint oil, sage oil; GlaxoSmithKline Consumer Healthcare, Bülh, Germany).

Artificial saliva was prepared by mixing 100 mL each of 25 mM K₂HPO₄, 24 mM Na₂HPO₄, 1,570 mM KHCO₃, 100 mM NaCl, and 1.5 mM MgCl₂, followed by adding 6 mL of 25 mM citric acid and 100 mL of 15 mM CaCl₂. The pH was adjusted to 6.7 with 5 N NaOH or concentrated (12 N) HCl. The solution was sterilized by autoclaving. After cooling to ambient temperature, human salivary α -amylase (Sigma-Aldrich Canada Ltd., Ontario,

Canada) and chicken egg white lysozyme (Sigma-Aldrich) were added at 1 and 0.1 g/L respectively^{40,41}. All media were thermostatically controlled at 37±1°C during the immersion/exposure periods.

Testing procedures

For each of the three suture materials, 100 samples were obtained thereof, resulting in a total of 300 suture samples, each measuring approximately 20 cm in length. All samples were immersed in artificial saliva. After 24 h, 60 samples ($n=20$ per suture material) were removed and either immediately tested for tensile strength (CG; $n=5$ per suture material) or immersed for 60 s in one of the three test media (TG-1, TG-2, and TG-3; $n=5$ samples per suture per test group). After 60-s immersion, samples were immediately tested for tensile strength.

The remaining samples ($n=240$) were either left in artificial saliva (CG; $n=20$ samples per suture material) or immersed for 60 s in the test media ($n=80$ per test media; 20 samples per suture material). After washing, the latter were returned to the artificial saliva bath for another 24 h. This process was repeated at 48, 72, 96, and 120 h, with 60 samples ($n=20$ per suture material; 5 samples per media group) tested for tensile strength at each time point.

An Instron material testing machine (8500/8800 system, Instron Ltd., High Wycombe, UK) connected to a computer was used to test the tensile strength of the samples. Tensile strength was determined by a single pull to suture failure, under a 50-N capacity load cell at a constant crosshead speed of 50 mm/min. Immersed/exposed suture samples were knotted with four simple square knots to each of the two fixed hooks on the Instron machine's fixation device; preliminary testing indicated that this experimental setup did not lead to suture failure at the hooks or knots. Maximum force in Newtons applied to the suture prior to failure was recorded as the breaking strength for that suture sample.

Statistical analysis

Data had normal distribution when tested with Shapiro-Wilk test for normality. Analysis of variance (ANOVA) was used to compare the mean tensile strengths of the suture materials. A p -value of <0.05 was considered statistically significant. Levels of significance were adjusted using the Bonferroni formula for multiple comparisons. All statistical analyses were performed using SPSS 17.0 (Statistical Package for the Social Sciences for Windows®, SPSS Inc., Chicago, IL, USA).

RESULTS

Table 1 lists the tensile strength results of the different suture materials. Tensile strengths of all the tested suture materials were not affected by immersion in artificial saliva (CG; Fig. 1). In TG-1, significant differences were observed for silk between Day 1 and Day 5 results (Fig. 2). In TG-2, Day 1 result of silk was significantly different from Days 4 and 5; for PLG and PTFE, their Day 1 results were significantly different

from Days 3–5 (Fig. 3). As with CG, immersion in TG-3 did not affect the tensile strength of any of the tested suture materials at any time point (Fig. 4).

Among the test media, TG-2 (100% myrrh oil) led to the greatest reduction in tensile strength. TG-2 negatively affected the tensile strength of all three

Table 1 Maximum tensile strength (Newtons) at failure, over time (mean±SD)

	Artificial Saliva (CG)			0.2% myrrh (TG-1)			100% myrrh (TG-2)			Commercial Rinse (TG-3)		
	Silk	PLG	PTFE	Silk	PLG	PTFE	Silk	PLG	PTFE	Silk	PLG	PTFE
Day 1	9.4±0.6	12.8±0.7	19.9±0.3	9.3±0.1	12.6±0.4	19.8±0.5	9.4±0.4	12.9±0.8	20.1±0.6	9.5±0.2	12.4±0.3	19.9±0.1
Day 2	9.3±0.1	12.7±0.6	19.8±0.1	9.1±0.3	12.6±0.3	20.4±0.9	9.1±0.3	12.7±0.8	19.7±0.2	9.3±0.5	12.4±0.5	19.9±0.7
Day 3	9.4±0.2	12.6±0.8	19.8±0.4	9.2±0.8	12.4±0.2	20.1±0.6	8.8±0.2*	12.3±0.7#	18.2±0.6**	9.3±0.2	12.3±0.1	19.8±0.9
Day 4	9.2±0.1	12.6±0.4	19.7±0.6	8.9±0.5	12.2±0.3	20.0±0.4	8.2±0.1**	11.2±0.7**	17.3±0.9**	9.1±0.8	12.4±0.1	19.8±0.5
Day 5	9.0±0.5	12.5±0.5	19.6±0.8	8.6±0.2**	12.2±0.1	19.3±0.2	6.8±0.6**	10.6±0.2**	16.4±0.1**	9.0±0.4	12.3±0.3	19.8±0.5

* Significantly different compared to corresponding control ($p<0.05$)

Significantly different compared to corresponding Day 1 value ($p<0.05$)

$n=5$ for all reported values

CG: Control group; PLG: Polyglactin 910; PTFE: polytetrafluoroethylene; TG: test group

Fig. 1 Line graph showing the changes in tensile strength over time for tested suture materials immersed in artificial saliva (CG).

Fig. 2 Line graph showing the changes in tensile strength over time for tested suture materials immersed in 0.2% myrrh (TG-1).

Fig. 3 Line graph showing the changes in tensile strength over time for tested suture materials immersed in 100% myrrh (TG-2).

Fig. 4 Line graph showing the changes in tensile strength over time for tested suture materials immersed in a commercial mouthwash which contained myrrh (TG-3).

Table 2 Maximum tensile strain (mm/mm) at failure at Day 1 and Day 5 (mean±SD)

	Artificial Saliva (CG)			0.2% myrrh (TG-1)			100% myrrh (TG-2)			Commercial Rinse (TG-3)		
	Silk	PLG	PTFE	Silk	PLG	PTFE	Silk	PLG	PTFE	Silk	PLG	PTFE
Day 1	0.57±0.2	3.12±0.2	0.83±0.2	0.78±0.1	1.54±0.1	1.13±0.1	0.71±0.2	0.96±0.3	1.07±0.2	0.58±0.1	2.15±0.1	0.77±0.3
Day 5	0.46±0.1	2.05±0.2	0.72±0.1	0.40±0.2	2.03±0.2	0.68±0.1	0.41±0.1	1.47±0.1	1.99±0.1*	0.69±0.1	2.95±0.3	1.11±0.2

* Significantly different compared to corresponding Day 1 value ($p<0.05$)

$n=5$ for all reported values

CG: Control group; PLG: Polyglactin 910; PTFE: polytetrafluoroethylene; TG: test group

tested suture materials. Silk and PTFE showed significant reduction in tensile strength by Day 3, while that of PLG was significantly reduced by Day 4.

Of the three suture materials, silk exhibited the greatest loss in tensile strength from myrrh exposure. At the end of the study (Day 5), the tensile strength of silk suture was reduced by almost 30% in TG-2, compared to less than 20% reduction in tensile strength for the other two tested suture materials. Silk was the only suture material negatively affected by TG-1. TG-3 (commercial mouthwash which contained myrrh) had no significant effect on any of the suture materials. Table 2 shows the maximum tensile strain values (at failure) on Day 1 and Day 5. Tensile strain values of PTFE in TG-2 were significantly different between Day 1 and Day 5.

DISCUSSION

The present *in vitro* study aimed to determine the effects of different concentrations of myrrh solutions on the tensile strength of three commonly used suture materials. Results showed that: (a) silk sutures were susceptible to tensile strength loss when exposed to 0.2% myrrh solution once daily for 5 days; (b) all tested suture materials lost tensile strength when exposed to 100% myrrh oil; and (c) myrrh-containing commercial mouthwash had no effect on suture tensile strength. To the best of our knowledge, this is the first study to investigate the effects of myrrh-containing solutions on the strength of suture materials.

Myrrh is composed of gum (57–61%), resin (25–40%), essential oil (7–17%), and impurities (3–4%)^{42–44}. Myrrh is widely used in Saudi Arabia as a home remedy^{45,46} because of its antiseptic⁴⁷ and astringent properties⁴⁸. Previous reports have indicated that myrrh can be used to treat several inflammatory conditions—as an antipyretic, an antiseptic, a stimulant, a mouthwash, as well as for treating spleen, liver, stomach, breast, head, nose and eye tumors^{49,50}.

The tensile strength of suture materials is an important property that indicates the ability of the material to withstand stress during knotting⁵¹. The three most commonly used intraoral suture materials, namely—silk, polyglactin 910, and polytetrafluoroethylene—were investigated in this

study. Three types of experimental media containing varying concentrations of myrrh were used. TG-1 contained 0.2% myrrh, which is the most common practice of myrrh use in the Saudi population³⁰. TG-2 contained 100% myrrh oil, a supraphysiologic test solution, which was used to determine whether myrrh would cause suture material deterioration at higher concentrations. TG-3 was an internationally available commercial mouthwash, Parodontax®, which contained myrrh leaf extract. The choice of experimental media allowed comparisons between various myrrh-containing solutions, ranging from local mouthwash (TG-1) to internationally available preparation (TG-3). Suture materials were exposed to the various test media for 1 min per day, which is considered as the average time mouthwashes are used intraorally^{52,53}.

Majority of the existing suture material literature is based on studies that were performed on skin and subcutaneous tissues^{51,54–56}. More extreme environments, such as that posed by pancreatic juice⁵⁷, were found to have significant effects on suture strength and integrity. Therefore, the strength of suture materials might be influenced by external factors presented by the physiological environment of the sutures. This is especially true with the sutures placed in the oral cavity because of the type of tissues involved, the constant presence of saliva, high tissue vascularization, and significant variations in local conditions (*e.g.*, temperature, acidity, osmolarity) arising from the consumption of foods and drinks and the use of toothpastes and mouthwashes.

In a study by McCaul and coworkers⁵⁸ which investigated the effect of chlorhexidine mouthwash on the absorption time on polyglactin 910 (PLG), it was reported that the mouthwash had no significant effect on the survival of suture material. PLG degradation due to tensile strength loss *in vivo* is secondary to proteolytic enzymatic degradation. PLG, when exposed to saliva, showed more rapid tensile strength loss, especially after 7 days⁵⁹. A recent *in vitro* study reported that 5-0 PLG degraded more rapidly than 4-0 PLG⁶⁰. PTFE was reported to have good resistance against infection and the action of tissue enzymes⁶¹.

In the present study, degradation rates of PLG and PTFE did not appear to be adversely affected by 0.2%

myrrh or Parodontax. However, the strength of silk was significantly reduced when exposed to even the lowest myrrh concentration. Although silk is classified as a non-resorbable material, it is known to be subject to proteolytic degradation but over a longer time⁶². It was also reported that the tensile strength of silk decreased upon exposure to saliva¹⁴. In the present study, all three suture materials exhibited significant strength reductions when exposed to 100% myrrh. The effect was most noticeable after Day 3. Although this concentration is not used intraorally, the result helped to confirm the effect of myrrh on suture materials.

The exact mechanism by which myrrh causes reduction in the strength of suture materials is unclear. Molecular analysis of the suture materials could probably provide more information on their interaction with myrrh. However, this is beyond the scope of the present investigation.

CONCLUSION

The tensile strength of silk sutures was significantly reduced by exposure to myrrh. For patients that routinely use myrrh-containing mouthwashes postoperatively, the findings of this study suggest that silk sutures might not be the optimal material choice. Appropriately designed clinical studies are needed to confirm the *in vitro* findings of this study.

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