Tissue Reactions to Cog Structure and Pure Gold in Lifting Threads : A Histological Study in Rats

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Research

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Abstract

Background: Thread lifting has become popular as a minimally-invasive suspension procedure, but there is little basic and clinical evidence in the literature on the long-term effects.
Objectives: The authors investigate the effects of two types of lifting threads in a rat model over the course of seven months.
Methods: The dorsal skin of 18 Wistar rats was implanted with a 20-mm fragment of one of three types of thread: nonabsorbable monofilament cog, pure gold (24 karat) with no cog, and pure gold-coated cog. Six rats were in each group. Tissue samples were harvested and histologically evaluated at one, three, and seven months.
Results: Histological assessment indicated (1) acute tissue reactions to the regular cog thread involving myofibroblasts and (2) delayed tissue reactions to the pure gold thread involving giant cells. The gold-coated cog thread showed a combination of the histological reactions associated with the cog thread and the pure gold thread, including faint early reactions, strong delayed reactions, and long-lasting capsule formation. Notably, the gold coating gradually came loose from the thread surface, suggesting that the release of tiny gold particles may promote longer-lasting tissue reactions.
Conclusions: The combination of cog structure and pure gold coating was evaluated for the first time in this study and results suggest that the gold-coated cog thread has clinical potential.

Keywords

thread lifting, gold thread, barbed suture, tissue reaction, foreign body

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Thread lifting has become popular as a minimally-invasive procedure for suspension of the facial skin and soft tissue. The technique was primarily developed to suspend the sustainable tissues, such as the malar fat pad and/or platysma, with or without open surgical approaches.[1-4] Various types of threads with special designs have recently been invented to attain more reliable and sustained effects or enable minimally-invasive access to the implant.[5-8] Among the most frequently-utilized materials are cog-type—or barbed—threads (eg, APTOS, Kolster Methods Inc., Corona, California), which have short "wings" projecting from the thread stalk and extending throughout the thread. The durability of each cog thread is thought to result from mechanical force as well as tissue reactions (eg, capsule formation) around the implanted thread.[5,6,9] Jang et al[9] performed a comparative study of the cog, monofilament, and multifilament threads implanted under the facial skin of a cadaver and under rat skin; the results at four weeks indicated that the cog thread showed the greatest holding strength and induced thicker capsular formation around the thread. Despite the initial results represented in studies such as Jang's, a longer period of postimplantation time is necessary to obtain clinically-meaningful insights and the long-term effects of cog thread utilization remain to be seen.

Threads are also implanted to produce capsules that lead to subsequent contraction and maintenance of the capsular structure, for preserving skin and tissue tension.[10]

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For this purpose, some practitioners have implanted a cogless gold thread. Ronde et al[11] reported that implantation of a gold thread caused a granulomatous reaction, including capsulelike structures with plentiful reticulin fibers, and that it may promote collagenous skin support. However, the authors provided no chronological description and the data were critically insufficient to describe the durability of the granulomatous reaction.

Although cog sutures are now widely selected as a minimally-invasive option, recent reports have claimed that the advertised longevity of their effect is not warranted[5] and has even been short-lived.[12] Thus, the role of barbed sutures in cosmetic surgery is still open to debate because of the unpredictability of long-term results and lack of scientific data from basic and clinical studies. Herein, we report the results of a comparative study of long-term tissue reactions (seven months) to thread implantation in a rat dorsal cutaneous implantation model. We evaluated the effects of a cog as a mechanical structure and pure gold as a safe tissue-reactive material. In addition, we included a gold-coated cog thread to assess any beneficial effects from the combination of features.

METHODS

A nonabsorbable monofilament cog thread (APTOS thread, 2-0 polypropylene thread with directional cogs; TOTAL Charm, Moscow, Russia) was obtained from the manufacturer and is herein referred to as the *cog thread*. A gold thread—hereafter, *gold thread*—was originally prepared by Tanaka Kikinzoku Kogyo KK (Tokyo, Japan), who also prepared the gold-coated cog thread (hereafter, *gold-coated cog thread*) by coating the same nonabsorbable cog thread described above with gold. The purity of the gold was kept higher than 99.99% (24 karats) in both threads. Morphological features of the threads were examined by scanning electron microscopy (S3500N, Hitachi, Tokyo, Japan). Threads were sputter coated with platinum/palladium before observation.

Eighteen Wistar rats weighing 250 g to 350 g were purchased. The study was designed in accordance with local laboratory animal guidelines. Surgical procedures were performed under general anesthesia with an intraperitoneal injection of pentobarbitone (50 mg/kg). Each rat had a 20mm-long fragment of one of the three threads inserted through a small incision on the back; six animals were used for each thread type. Tissue samples (ie, thread and surrounding subcutaneous tissue) were obtained and subjected to histological examination at one, three, and seven months after thread implantation.

After excision, the tissue samples were fixed in 10% formalin and embedded in paraffin. Sections transverse and longitudinal (4 µm) to the thread axis were visualized with hematoxylin and eosin staining, with Elastica van Gieson staining, or by immunostaining for α smooth muscle actin (αSMA). Following heat-induced antigen retrieval in citrate buffer, sections were incubated with mouse anti-αSMA antibody (clone 1A4, Dako, Glostrup, Denmark) at 1:100 dilution for one hour at room temperature. Detection utilized the Envision Plus HRP secondary anti-mouse antibody (Dako) and 3,3′-diaminobenzidine; slides were counterstained with hematoxylin.

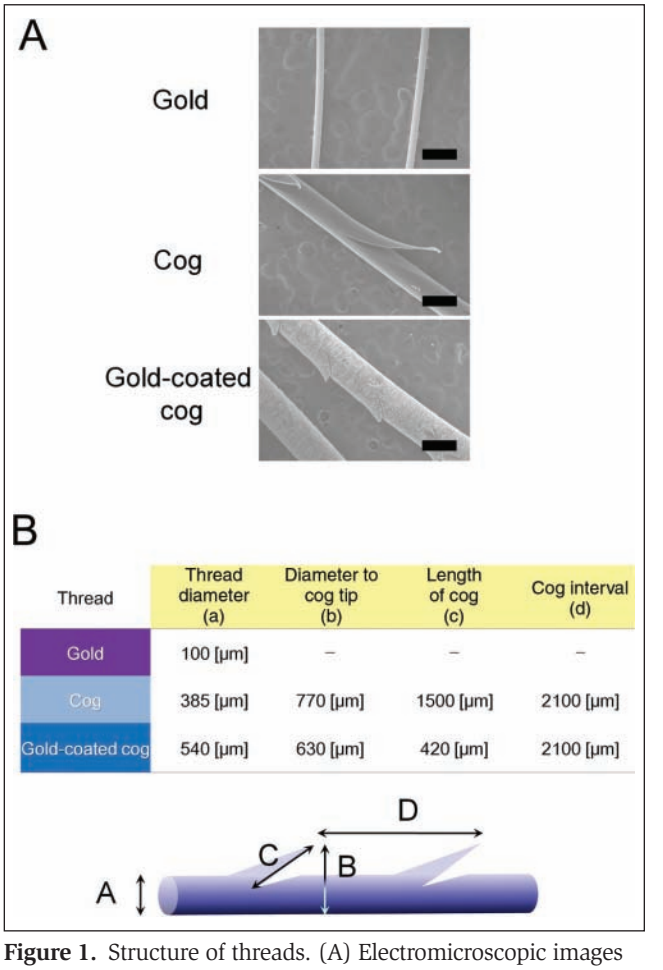

Figure 1. Structure of threads. (A) Electromicroscopic images of pure gold thread, polypropylene cog thread, and gold-coated cog thread. Bar = 500 µm. (B) Morphometric data of each thread: (a) diameter of the main stalk of a thread, (b) maximum diameter of a thread (measured up to the cog tip), (c) inner length of a cog, (d) length of cog interval.

In addition to careful inspection under a light microscope, an image of each sample was reconstructed with overlapping photomicrographs (200× magnification) and evaluated. For quantitative assessment of histological features, areas of capsulelike structures in the hematoxylin and eosin–stained images—along with pink-colored and yellow-colored areas of the capsules in Elastica van Gieson–stained images (collagen and cellular components, respectively)—were measured and calculated with image-processing software (Photoshop, Adobe Systems, San Jose, California). The number of αSMA-positive myofibroblasts in the thread-surrounding capsules was counted. The data were calculated with mean values for each group.

RESULTS

The structural features of each thread were measured via electron microscopic assessment (Figure 1). The thread diameter was 100 µm in the gold thread. The cog thread was 385 µm in diameter and 770 µm at the tip of cog (Figure 2).

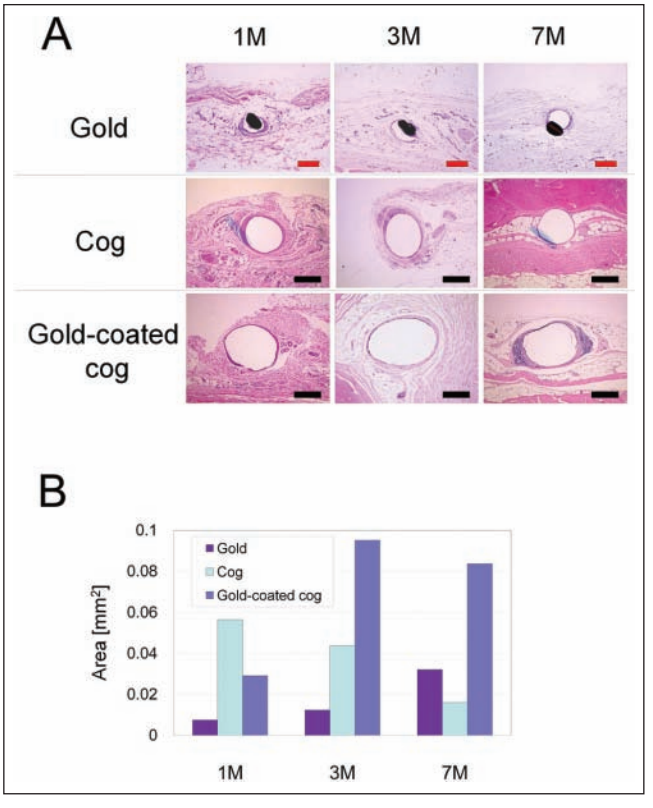

Figure 2. Histological evaluation of capsule formation. (A) Hematoxylin and eosin–stained sections of samples harvested at one, three, and seven months. Red bar = 200 μm, black bar = 500 μm. (B) Cross-sectional area of thread capsules, as measured with image-processing software.

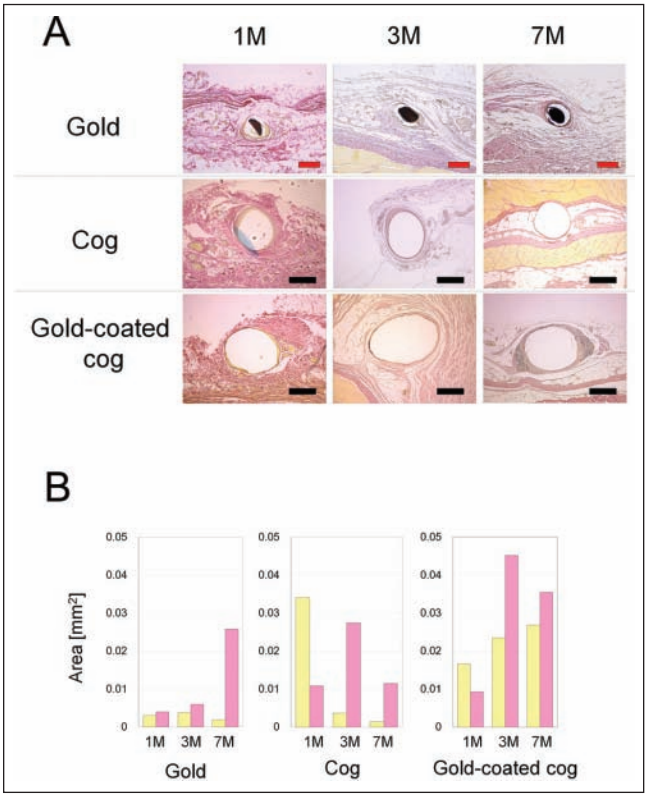

Figure 3. Qualitative evaluation of thread capsules (capsule composition). (A) Elastica van Gieson–stained sections of samples harvested at one, three, and seven months. Red bar = 200 μm, black bar = 500 μm. (B) Composition of thread capsules. Collagenous areas (pink) and cellular areas (yellow) were measured separately with image-processing software.

The gold-coated cog thread was 540 μm in diameter (630 μm at the tip of cog) and the gold coating was approximately 80 μm. The surface of the gold thread was manufactured to be smooth, but tiny spinous protuberances were occasionally observed, possibly because gold is mechanically vulnerable. Intervals between cogs for the cog thread and the gold-coated cog thread were the same (2100 μm), whereas the diameter of the cog tip was smaller in the gold-coated thread, probably because the angle of the cog was reduced by the gold coating.

Histological evaluation revealed that all threads were surrounded by capsulelike structures at all time points (one, three, and seven months). The thickness (Figure 2) and composition (Figure 3) of the capsule were evaluated, as was the number of αSMA-positive cells (myofibroblasts) (Figure 4).

The gold thread was covered with a thin capsule at one month, which gradually thickened up to seven months (Figure 2). On the contrary, the capsule around the cog thread was the thickest at one month and gradually decreased over time. The gold-coated cog thread showed features of the other two types; namely, the capsule was thinner than that of the cog thread at one month but showed an increase in thickness thereafter. This chronological alteration may have resulted from the gold surface.

In Elastica van Gieson–stained sections, collagen fibers were stained in pink, whereas cellular components appeared yellow (Figure 3A). The gold thread capsule was composed primarily of cellular components at one month and gradually replaced with collagen fibers thereafter. The transition of the capsule component was seen earlier in the cog thread, in which the capsule was almost completely replaced with collagen fibers at three months. The gold-coated cog thread showed features that were distinct from the other two thread types. At three and seven months, the gold coating was shed from the thread surface into the thread capsules and tiny gold fragments were detected in the capsule (Figure 3A). Multinucleated giant cells were found in the capsules of the gold and gold-coated cog threads, although such cells were not detected in the capsules surrounding the polypropylene cog thread.

αSMA-positive cells were identified as myofibroblasts (Figure 4A) and these were counted in the capsule (Figure 4B). There were few myofibroblasts around the gold thread throughout the study period, but they demonstrated a moderate increase over time. The cog thread group showed a much greater number of myofibroblasts at

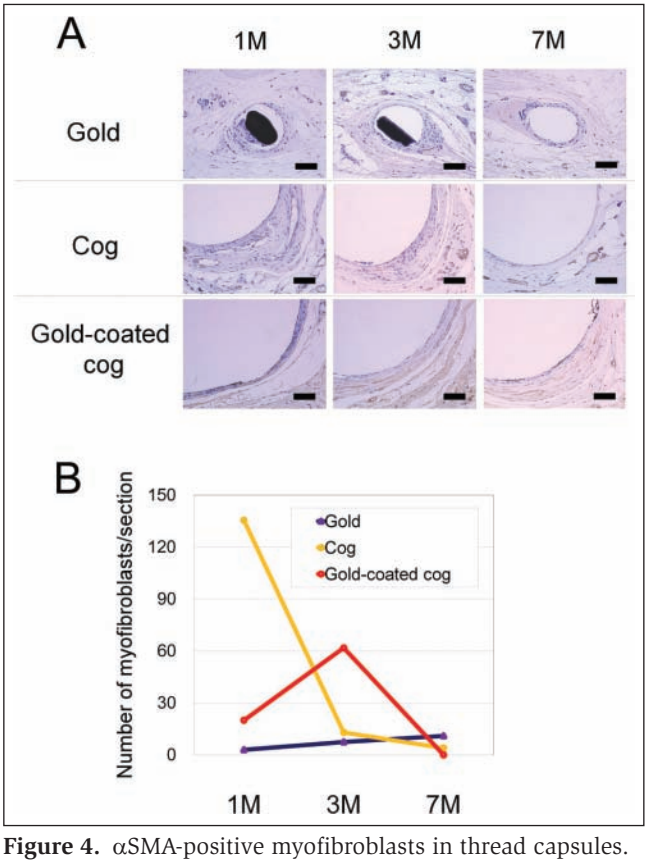

Figure 4. αSMA-positive myofibroblasts in thread capsules. (A) Immunostained sections for αSMA from samples harvested at one, three, and seven months. Black bar = 50 μm. (B) Number of αSMA-positive myofibroblasts in thread capsules at one, three, and seven months.

one month compared to the other thread groups, although the myofibroblasts almost disappeared by three months. The gold-coated cog thread initially showed a low number of myofibroblasts at one month, many more myofibroblasts at three months, and a disappearance of myofibroblasts by seven months.

Although not quantified in our data, vascular reactions such as neogenesis and dilatation of vessels were observed around the capsules. These changes were most prominent in the cog thread samples. The gold thread showed comparatively weak angiogenic reactions, whereas reactions around the gold-coated cog thread were intermediate.

DISCUSSION

This study investigated two factors associated with lifting threads: the structural addition of a cog and the material addition of gold. The cog thread had a larger cross-sectional diameter and an irregular shape, which induced both mechanical force and greater injury to the implanted tissue. Thus, the cog likely acted as not only a hook for tension of the skin and/or tissue, but also as an inducer of surrounding tissue reactions. However, gold has been used in many clinical applications (eg, eyelid weight in facial palsy patients, material for odontologic treatment) without substantial immunologic reactions. Although gold implantation may cause local and systemic adverse reactions,[13,14] pure gold (24 karats) may be a clinically-useful material that is nonimmunologic, nonallergic, antibacterial, and nonoffensive to the organism.[11] Although there is little knowledge about or widespread use of the gold thread (either as a cog or as plain thread), this study was conducted to provide a scientific evaluation of pure gold as material on a lifting thread.

Our results suggest that the gold thread showed weak but long-lasting tissue reactions throughout the study period, whereas the polypropylene cog thread exhibited strong but short-term reactions. According to Jang et al,[9] who compared histological reactions to a monofilament nylon thread and a cog thread under rat dorsal skin, the cog thread tends to induce a thicker capsule with a higher density of myofibroblasts than does a monofilament thread at four weeks postimplantation. Our histological samples at one month also showed a thick capsule with a large number of myofibroblasts, which almost disappeared by three months and the capsule was dramatically decreased in thickness by seven months. Our results, which demonstrate that capsule thickness and collagen content gradually increase over time, are in accordance with a previous finding[11] showing that implantation of gold induced mild but long-lasting capsule formation. Multinucleated giant cells observed around the gold thread were considered to have originated from macrophages and were a typical feature seen in foreign body granulomas. Thus, our results suggest that gold thread implantation causes sustained capsule formation with granuloma-like features, which may support skin/tissue tension for a prolonged period.

The use of a gold-coated cog thread has never been described and, to our knowledge, this study is the first to evaluate the effects of adding gold coating to lifting cog thread. Although a previous animal study using cog threads showed the intimate association between granulomatous reactions and tensile strength,[9] this study focused on assessments of granulomatus reactions. The gold-coated cog thread showed a combination of histological features specific to both the gold thread and the cog thread: weak early reactions, strong delayed reactions, and long-lasting capsule formation. Notably, the gold coating was gradually shed from the thread surface; we speculate that the release of tiny gold particles may help promote longer-lasting tissue reactions. More stable and durable mechanical suspension and stronger contractile reactions may be clinically obtained with the gold-coated cog thread. Our study is limited by the animal model (rather than human), as well as by the fact that skin and tissue tension were not measured, but it does provide the groundwork for future clinical studies.

CONCLUSIONS

Our results show that a gold-coated cog thread engenders tissue reactions that combine features of cog threads and gold threads, including more stable and durable mechanical suspension and stronger contractile reactions. We therefore conclude that the gold-coated cog thread has clinical potential.

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Disclosures

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