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Review

Contemporary view on thread lifting: Histological and anatomical approaches

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Abstract: Currently, thread lifting in aesthetic facial rejuvenation is not the top priority, but nevertheless its popularity continues to gain momentum. In connection with increasing popularity, the number of issues related to thread lifting and its undesirable side effects also increases. In this publication, an analysis of Russian and international databases was carried out, including MedLine, PubMed, elibrary.ru, Wiley Online Library, Web of Science, over the period from 2010 to 2020 (10 years). In the search, the following keywords were used both in Russian and English: threads, thread lifting, rhytidoplasty, face rejuvenation, face lift, cog threads, Aptos, suture material. As a result, of all available publications, 51 articles were left for further analysis, on the basis of which the nuances of thread classification, histological changes in tissues in response to thread implantation, along with anatomical basics and features during the procedure of thread lifting were analyzed. The effectiveness and duration of the thread lifting effect is still subject to debate. Hence, sometimes, it is possible to identify the duration of the effect in the same study ranging from 1 month to 2 years. Despite the long history of thread lifting, there are still unresolved issues that need to be covered.

Keywords: thread lifting, cog threads, face rejuvenation.

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Introduction

The most rapid development of employing various thread techniques for facial tissue correction in Russia has occurred over the past decade. Even 10-15 years ago, the thread-lifting procedure was carried out by an extremely limited list of specialists, whereas at present, in one form or another, threads are used in rejuvenation programs by many cosmetologists – unfortunately, some of them lacking higher medical education. Currently, interest in methods of thread correction of the face and body does not fade away, while there are very few publications in peer-reviewed journals regarding the effectiveness of the technique [1]. In addition, there is a fairly large amount of disparate marketing information and offers regarding various types of threads and techniques on the market. Most articles covered just a few aspects related to thread lifting: classification of thread lifting, histological studies after implantation of threads made of different materials, clinical studies of the efficacy and safety of certain types of threads, studies on dissection material, or clinical cases. Thus, the goal of our review was to summarize and systematize the scattered information about the facial thread lifting.

Material and Methods

In our study, an analysis of Russian and international databases was carried out, including MedLine, PubMed, elidrary.ru, Wiley Online Library, and Web of Science over the period from 2010 to 2020 (10 years). In our search, we used the following keywords: threads, thread lifting, rhytidoplasty, face rejuvenation, face lift, cog thread, Aptos, and suture material, both in Russian and English.

Results and Discussion

The initial search yielded 197 articles. After filtering out duplicate articles, publications on facial plastic surgery and papers on aesthetic facial rejuvenation without thread use, 51 articles remained, which were further analyzed in this study.

Thread lifting: History and terminology

The history of using cog threads is much more than 10-15 years. Threads, like sutures, are used in various fields of medicine to connect tissues. For example, the first mention was found in a Chinese treatise on medicine 2000 years BC. Until the middle of the 20th century, threads from various materials were used, but all of them had a smooth surface. The first patent for barbed threads

was received by Alcamo J.H. (1961), who made cuts on a polypropylene thread with a scalpel for better fixation in tissues. It was a suture with unidirectional cuts to repair tendons, and later a suture with cuts in both directions for better fixation was patented (Alan McKenzie, Tanner, 1972) [2].

Subsequently, work continued on the introduction and development of barbed threads used for facial rejuvenation during plastic surgery (Fukuda, 1984; Ruff, 1994) [3], and since the mid-1990s, a large number of different proposals have appeared for the use of nonabsorbable barbed threads from various materials for facial rejuvenation. Since 1994, elastic polycaproamide threads (Tissulift), developed by N. Serdev, have been used, and since 2003, Sasaki has proposed using suture threads based on polytetrafluoroethylene (Gore-Tex) for rejuvenation [4].

In Russia, in 1998, M.A. Sulamanidzhe suggested using polypropylene thread with notches for lifting the tissues – Aptos, which was announced at the International Conference in 2002. Since then, the Aptos product has become popular all over the world. After that, a thread with an increased number of notches was announced in 2003 by Woffles Lift (Wu W.T.L.), and in the USA after 2004, G. Ruff received approval for Contour Threads, which had spiral arrangement of notches (like DNA). N. Isse proposed using knots with resorbable cones instead of notches on a polypropylene thread as a fixing element of the thread [5].

Despite the variety of different nonabsorbable suture materials, polypropylene remained the most widely used option (as the most predictable and bioinert material). Since the 2000s, the era of resorbable sutures has begun, with polydioxanone (PDO) sutures being the most developed in South Korea, and polycaprolactone or polylactic acid sutures prevailing in Russia, Europe and the United States.

There is a slight violation of semantic logic in the term *'thread lifting*': for example, the word 'lifting' presumes moving tissues upward, with fixation, but not all types of threads involve, actually, lifting tissues. In 2014, D.A. Gruzdev offered a classification of threads, including based on the effect of their use, which included biostimulating, reinforcing and lifting threads. This classification is convenient in practice, including when the consultation with a patient before the procedure, to discuss the expected effect of thread lifting, the expected recovery time and the longevity of the result.

Thread classification

In cosmetology, threads are used, the setting of which does not require tissue incision with subsequent suturing. After the implantation of threads, there is a histological reaction of tissues (regeneration and neocollagenesis), the creation of a skeleton of tissues, or movement of tissues. Depending on the prevailing effect, three types of threads are distinguished [6]:

1. Biostimulating
2. Reinforcing

The main effect of employing biostimulating threads is the activation of regeneration and subsequent neocollagenesis, due to the reaction of tissues to the chemical composition of the thread (and the presence of a foreign body), while the reinforcing and lifting effect is minimal or nonexistent. Most often, biostimulating threads are quite thin – up to 3-0 USP, they can be both textured or smooth.

Reinforcing threads are introduced with the aim of fixing soft tissues; they are able to create a framework in the area of application, followed by a histological reaction of regeneration and neocollagenesis. Most often, reinforcing threads have a larger diameter (2-0 USP, 1-0 USP) and have a fixing texture (notches, cones, etc.). An important condition for reinforcing threads is the bidirectionality of the notches: a thread that has notches in one direction is not able to hold itself and hold the tissue (without additional fixation). The notches can be mirrored towards the center or alternate.

Lifting threads always have fixation to the underlying dense inactive tissues (more often in the upper-lateral part of the face), the movement of soft tissues occurs during the procedure, and the subsequent return of tissues to their original position is impeded by the textural elements of the thread (notches oriented towards the fixation point – i.e., converging, cones, teeth, dents, etc.). Another option for fixing the displaced soft tissues is by forming a ring when placing the threads. Most often, lifting sutures have a size of 2-0 USP or 1-0 USP, which provides mechanical strength of the suture. They are equipped with needles that provide fixation of the suture to the underlying tissues with subsequent tissue movement. If the lifting threads were installed without moving the tissues, they provide solely a reinforcing effect.

Thread material

The threads used for facial rejuvenation are made from suture material. The requirements for such suture material include its non-allergenic, non-immunogenic, non-carcinogenic, and biocompatible properties [7].

By the material, from which the threads are made, they can be:

1. Nonabsorbable (permanent, nonresorbable) – threads based on polypropylene, silicone, gold, platinum and other non-biodegradable materials;

2. Absorbable (resorbable) – threads based on PDO, caprolactone, polylactic acid and other biodegradable materials.

Most thread types are not stretchable (i.e., not elastic), but in recent years, nonabsorbable threads based on silicone coated with polyester have appeared: these are elastic threads. Besides, such thread is represented by interlacing of filaments rather than being monofilament [8]. The creators of such thread position it as creating a more natural movement of soft tissues, additionally to improved collagenesis, due to the interweaving of collagen fibers between the thread filaments.

Threads made of precious metals (gold and platinum) were initially claimed reinforcing, but with growing experience of their use, just their biostimulating function was noted; moreover, fragmentation of threads was often detected on radiographs [9].

The use of suture material based on polylactic acid was facilitated by data on the revitalizing effect of polylactic acid on fibroblasts. Threads based on polylactic acid (poly-L-lactide, PLLA) are biocompatible and do not cause rejection; they are bioactive, sensitive to enzymatic and chemical hydrolysis, and degrade after an average time span of 12 months (decomposing into carbon dioxide and water). Polycaprolactone has similar characteristics and revitalizing effect, which is somewhat less pronounced, but at the same time the threads of polylactic acid are stiffer and more fragile. To maximize positive characteristics of the threads, it is

possible to combine polylactic acid and polycaprolactone into a copolymer [10, 11].

There are also the so-called 'partially resorbable threads' consisting of a nonabsorbable material (polypropylene), while the fixing elements on the thread surface (cones) are made of absorbable material (polylactic acid, more precisely a copolymer of glycolic and polylactic acids) [12].

Currently, nonresorbable sutures are used less due to delayed side effects, such as migration, chronic granulomatous inflammation, foreign body reaction and chronic pain syndrome [13-15].

Histological response after thread implantation

In response to the subdermal insertion of the thread, regeneration processes are triggered, similar to the wound healing process: inflammation, regeneration, scar formation and reorganization [16]. When implanting threads from various materials, a similar reaction is noted:

- Signs of weak inflammation with frail infiltration of histiocytes with single neutrophils in the area around the thread, the presence of macrophages, tissue edema (more pronounced at 2-3 weeks and declining by the 90th day) [17];

- Newly formed collagen fibers around the thread (oval-shaped fibrous capsule with fibroblasts inside), the process begins at 2 weeks, and the predominance of collagen structures over cellular assemblages is histologically obvious after 180 days [18];

- After 2-3 months, the growth of elastin fibers around the thread is also histologically noticeable;

- On the outer side of the fibrous capsule, neovascularization occurs (an increase in the density of small vessels) [19];

- Conducted studies highlight the absence of eosinophils, necrobiosis, granulomas, dystrophic changes in the hypodermis, nerve fibers and skin appendages, along with a vascular thrombosis [20, 21].

Typical histological changes in tissues may depend on the type of implanted threads:

- Enlargement of elastin fibers with implantation of polylactic acid threads;

- Minor reduction of subcutaneous adipose tissue in response to PDO thread implantation [22];

- An increase in the amount of collagen type I occurs when a PDO-based multifilament thread is implanted or when a monofilament polylactic thread is added to a PDO-based thread [10];

- Supplementary histological reactions of surrounding tissues were noted during implantation of cog threads when there was a greater number of myofibroblasts in the tissues, and the formation of a thicker fibrous capsule, along with a thickening of the dermis, were noted [23, 24]. Presumably, cog threads create significant tissue trauma, whereas myofibroblasts provide tissue contracture.

Histological evaluation of tissue with implanted gold threads 10 years later exhibited an unexpressed inflammatory reaction with several giant cells, and threads were surrounded by a fibrosis capsule and separately existing fibrous cords with moderate monocytic infiltrate [25].

Molecular analysis showed an increase in collagen type I and TGF-β1 in response to implantation of the PDO-barbed thread for 7 months and a corresponding initial infiltration of inflammatory cells and fibroblasts around the implant, followed by the formation of a fibrous capsule [26].

Degradation of resorbable threads in tissues begins with hydrolysis due to the saturation of the thread with moisture. When the threads are saturated with moisture, they become weaker and unable to provide a mechanical effect on tissue retention [27]. Reabsorption occurs from the periphery to the center of the threads due to the action of the histiocytic reticular system [19]. The presence of non-reticulated hyaluronic acid may accelerate the degradation of threads (based on PDO) and serve a catalyst for the hydrolysis of the thread 24 hours after the contact, as was shown on the example of PDO threads [28].

PDO threads undergo the most rapid degradation; for example, smooth 4-0 USP threads begin losing their shape 12 weeks after the implantation; they fragment after 24 weeks, and dissolve after 48 weeks [29]. Threads made of polylactic acid are subject to a longer degradation, while those from polycaprolactone [Poly (ε-CaproLactone)] have an even longer resorption [11].

Most studies on thread resorption are carried out on animals, whereas clinical studies on patients often demonstrate a longer period of clinical effect, due to the formation of a fibrous capsule in place of the threads, already after the resorption of PDO threads [30, 31].

Anatomical aspects of thread-lifting procedure

With age, there is a loss of support for the soft tissues of the face, hence their displacement downward and medially. Thread lifting is an alternative way to prevent age-related changes or return tissue to its original position [32], but this method is not an alternative to surgical facelift with comparable results [33].

The effectiveness of thread lifting is based on 2 mechanisms: histological (the formation of fibrosis around the thread) and mechanical (movement and retention of tissue due to incisions) [27].

When conducting thread lifting, there is no surgical separation of tissues, and the basis for this procedure is the presence of spaces (middle and lower premaxillary), described by Mendelson [34]. Along such spaces, tissue movement is performed: more superficial tissues slide over deeper ones [3].

The main anatomical layer for thread implantation is the layer of surficial facial fat pads. The latter are displaceable structures of soft tissues of the face, while the movement vector of the face is higher than that of the muscle-fascial layer. The threads are fixed in the subcutaneous fat due to the presence of a connective tissue component. The connective tissue component of subcutaneous adipose tissue is a complex of retaining ligaments, and the mechanical effect of the threads is associated with their fixation in the required position [34].

Threads with notches (or cones) are fixed to the connective tissue elements of the subcutaneous adipose tissue. After the thread is pulled through, and the soft tissues are moved to the fixation point, the notches open (like umbrellas) and hold the displaced tissues in this position; thus, the notches create a support structure for the corrected facial soft tissues. The retention of tissue by the notches in the initial position is not 100%. Almost always, after movement and tension of tissues, there is a weakening of tension and some 'sliding' of tissues along the threads in the opposite direction. In this case, partial (local)

weakening of the thread could lead to such undesirable event as asymmetry [35].

Despite the fact that there are publications on the safety and efficacy of deep buccal fat reposition on cadavers [36], this method remains controversial, and the properties of soft tissues (including moisture filling, muscle movement, and vascular fullness) on cadaver material versus in vivo have significant differences. Also, the studies conducted on live patients are extremely limited in the number of patients [37]. The use of threads below the subcutaneous adipose tissue level may reduce the efficacy of the procedure (risk of displacement, rupture of the thread), as well as increase the risk of adverse events (damage to blood vessels and salivary gland, prolonged or chronic pains) [38].

Conducting thread-lifting procedure

The Korean school of thread lifting uses PDO-based sutures (more often in recent publications), or else sutures based on polypropylene (more often in earlier studies) with notches, with access from the temporal region [39, 40]. There are also methods of threading in deep layers (buccal fat pack) or by means of using a loop through deep and superficial fat, which is not safe from an anatomical standpoint [41].

The European and Russian schools of thread lifting were initially dominated by the use of threads based on polypropylene, then polycaprolactone with polylactic acid was chosen as the preferred resorbable material. Most of the opinions, articles, manuals on the thread-lifting technique from foreign authors consider the excess tissue as a limitation on the use of this technique: for them, the ideal patient has minimal signs of aging, usually 35-45 years old [42]. At the same time, the recommendations of Russian specialists, as a rule, do not consider this trait a limitation [35].

A sufficiently large number of techniques involves a vector of tension (movement) towards the temporal region [43]; in addition, many techniques involve incisions at the place of the thread fixation, which is not permissible for use by cosmetologists.

Prior to the thread lifting, as a rule, local anesthesia is applied: topical cream when working with biostimulating threads, or infiltration with lidocaine (with the addition of epinephrine or adrenaline, and sometimes sodium bicarbonate solution is added) when working with reinforcing and lifting threads [44]. In some cases (intraoperative use of thread-lifting procedures by plastic surgeons), the procedures are conducted under general anesthesia. Intravenous sedation is used, for example, during the procedure in South Korea.

To reduce the risks of adverse events after the procedure, in addition to observing the basic rules of thread lifting, it is necessary to pay additional attention to antiseptics. Hence it is recommended to treat the face three times with antiseptic solutions, control the hair (to prevent them from getting subcutaneously during the implantation of the thread) and cover the patient with sterile sheets before the main procedure [45].

Efficacy and duration of the effect

There are very few long-term studies on the efficacy of thread lifting. In this regard, there was (and still remains) a rather skeptical tone of some publications and comments on publications [1]. According to various studies, the duration of the thread-lifting effect can vary greatly, most often depending on used threads and individual characteristics of the patient. According to various studies, the preservation of the result after thread lifting was for 12-24 months in 70% of patients, while the skin was becoming more elastic after that period; the duration of the effect in the middle third of the face was longer than in the area of the lower jaw (in the platysma zone) [46]. Other studies exhibited clinical efficacy from 1 month to 2.5 years [35, 47].

A large number of studies demonstrated that the duration of the effect from nonresorbable threads was longer than from threads made of absorbable material; although, according to Consiglio F., 2016, threads made of non-biodegradable material may lose their elasticity up to 56% within a year [48]. The unambiguity of published evidence is only related to the trend towards an increase in complications from the introduction of permanent threads.

Discussions on the duration of the effect of absorbable threads continue. It is believed that PDO threads have the shortest duration of the desired thread lifting outcome [49, 50]; however, the number of thread-lifting procedures has a clear current preponderance towards absorbable materials. The efficacy and durability of thread lifting is significantly higher when combined with other aesthetic procedures [51].

Conclusion

At the moment, thread lifting has undergone through the sufficient number of studies allowing us to talk about the effectiveness and safety of the method. Histological studies were carried out on various materials used for thread lifting, and they showed the difference in tissue response to thread implantation. Clinical efficacy is not so unambiguous, as data on the duration of the effect varied from 1 month to 2.5 years. The data on the severity of the clinical effect also varied: some publications gave a negative assessment of the clinical effect, while other studies confirmed highly satisfactory effect of the procedure. At the same time, it is worth noting the complexity of assessing the clinical effect. Most studies were based on subjective scales of satisfaction with aesthetic results, or on the results of photographic documentation. From the standpoint of safety, the use of thread lifting has been evaluated in histological, dissection and clinical studies.

Despite the large number of publications on thread lifting, there is still a dire need in studies on clinical application of thread lifting, aimed at finding an optimal implantation technique and choosing the most suitable patients for the procedure.

Conflict of interest

Authors declare no conflicts of interests.

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