USE OF POLYDIOXANONE THREADS IN FOREHEAD WRINKLE CORRECTION

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ABSTRACT

The two major factors involved in the formation of static wrinkles in the upper face are repetitive muscle contraction and aging (loss of dermal collagen and matrix material leading to reduced dermal support). Compared with other facial muscles, the frontalis and corrugator muscles usually retain their muscle volume and even undergo hypertrophy to compensate for age-related ptosis and loss in visual acuity, which intensify the wrinkles. Polydioxanone (PDO) has been in use for over three decades in tissue engineering and surgery. It's safe and used on a daily basis in hospitals for wound closure and studies illustrated its beneficial effects when use in management of forehead wrinkles.

Key words: Forehead Wrinkles, Polydioxanone (PDO).

I. FOREHEAD WRINKLES

Forehead wrinkles are due to a combination of genetic and environmental factors, especially damage ultraviolet light. The contributions of both must be analysed when patients attend for treatment. Make sure too that they do not expect the ablation of furrows as this requires carbon dioxide laser resurfacing for maximum effect (1).

Major factors involved in forehead wrinkle formation include dynamic frontalis muscle movement and skin aging with reduced collagen and other matrix material. Compared with other facial muscles, the frontalis muscle usually maintains its muscle volume and sometimes even undergoes hypertrophy to prevent ptosis. Relative muscular hypertrophy of the frontalis might also play a role in forehead wrinkle formation due to decreased skin elasticity and photo-aging. Botulinum toxin and hyaluronic acid filler are effective treatment modalities that do not necessitate invasive procedures and have minimal adverse effects. However, some patients may be hesitant to use toxin or insert filler for many reasons such as the potential risks of ptosis, unnatural facial movement, and skin necrosis related to vascular occlusion by fillers (2).

Recently, polydioxanone (PDO) filaments had been introduced for wrinkle reduction with multiple applications of single PDO filament in various areas of the face. Different lengths, numbers, and thicknesses of PDO filaments and various kinds of insertion techniques have been developed by dermatologists and plastic surgeon to improve the outcome of facial lifting. However, a single PDO filament is very thin and weak so can easily dissolve within several months. To overcome this limitation, stent-shaped multi-PDO scaffolds were developed to support sustainability in wrinkle-folded skin and to stimulate new collagen formation by the subcision effects of surrounding skin (3).

Wrinkles are a natural result of ageing and are found in nearly all elderly persons. However, photo-damage and habits such as smoking, and alcohol consumption can accelerate wrinkle formation. Recently, a variety of treatments such as lasers, radiofrequency, plastic surgery, toxin, and fillers have been utilized for wrinkle correction. In some cases, these effective and powerful modalities have been used in combination to achieve a
better clinical outcome. In recent years, PDO has been increasingly used for lifting and tightening of facial wrinkles. Non-absorbable polypropylene was widely used in the past, whereas absorbable PDO has recently become a popular replacement (3).

**Polydioxanone Threads for Skin Rejuvenation and Facial Tissue Anti-Ptosis**

Polydioxanone (PDO) has been in use for over three decades in tissue engineering and surgery. It's safe and used on a daily basis in hospitals for wound closure. There are no problems with allergic reactions or long-term complications. Compared to other absorbable threads, PDO is the longest lasting. It takes about 130 – 180 days to be resorbed and replaced by fibrosis. The Korean FDA approved mono 6-0 PDO threads in 2011 for the following indications: (4).

1. neo vascularisation,
2. collagen type 1 and 3 regeneration and
3. lipolysis. Platelet-rich plasma (PRP) also gives neo-vascularisation and collagen regeneration via growth factor release, so that's why PDO threads combined with PRP gives an enhanced effect (4).

A large number of fibroblasts infiltration around the pair of threads shows an increase in new collagen fibres and a reduction in the number of fat cells—that's the lipolytic effect. It's not a significant lipolytic effect though, so if lipolysis is desired then insertion of threads combined with a lipolytic agent such as Aqualyx can be used to enhance the effect. However, the patient must be warned to expect gross swelling of the treated area (5).

Fibrous bridging can be observed between the threads and the perimysium of the muscle and also between the threads and the dermis. So, fibrous bridging occurs in all directions and fibrosis is not confined to the immediate area around the threads. Two to three months later, contraction (tightening) of the fibrous bridging takes place. In summary, skin remodelling takes place because of more capillaries, more fibroblasts, more collagen and less fat cells (6), wrinkles due to the “facial scaffolding” not being able to provide as much support. Thread lifts or suture lifts involve the use of threads or sutures made from materials used in surgery to close wounds. When threads are placed under the skin they can tighten and lift loose or sagging areas in various parts of the face and body to help reduce the effects of gravity and ageing, or they can be used to rejuvenate the face (4).

There are three main types of threads currently available: polydioxanone (PDO), polylactic acid (PLA) and polycaprolactone (PCA). PDO threads have been around the longest and are made of a synthetic biodegradable polymer that has been used in surgery for many years. PDO threads are absorbed into the body over 6 months by hydrolysis and work by triggering fibroblasts to produce more collagen in a targeted area. There are three main types of PDO threads used: mono, cog and screw threads. Mono threads are smooth without barbs and are anchored to a point on the face or the scalp. They mainly tighten the skin and provide a small amount of lift. Cog threads have barbs which hook onto the skin to provide support and lift the sagging tissue. Screw threads have one or two intertwined threads around the needle and provide good volume restoration to sunken areas of the skin. The production of collagen around the threads and their barbs helps to restore volume and improves the skin texture and elasticity resulting in a natural aesthetics outcome (5).

After PDO threads, PLA threads were developed. They are made from a biocompatible polymer derived from lactic acid that has been used in many applications such as orthopaedic pins and sutures. PLA threads are resorbable and regenerate collagen over a longer time than PDO threads. PLA threads use cones to hook to the tissue and increase the volume of saggy areas therefore helping to restore shape to the facial area as well as providing a lift (6).

PCA threads are the newest threads and are bio-absorbable, monofilament suspension threads of synthetic origin (caprolactone). They work by regenerating collagen over a longer time than PDO and PLA threads. They leave behind a collagen structure that provides support for the skin, tightens the skin and prevents it from sagging. Due to the fibrotic reaction caused by the threads, the lifting and stretching action will continue even after the threads have been resorbed. The process of thread breakdown produces molecules of small molecular weight which subsequently induce the production of collagen and Hyaluronic acid by the skin. The resulting skin is more moisturized, revitalized and firm with a long-lasting result. (7).
Before deciding what type of thread to use we must consider the treatment indications and what we are trying to achieve, facial lift or facial rejuvenation. If a patient wanted tissue lifting PDO monofilament threads would be unsuitable as they are placed superficially, are completely smooth and without barbs. While they produce a regenerative and firming effect that visibly improves skin quality, they do not provide an effective amount of tissue lifting. To achieve a powerful lift with improvement in facial tightening and rejuvenation, barbed threads must be used. The barbs along the threads act as cogs to clasp the skin creating tension in the thread which lifts and suspends the facial area. Collagen is formed around the threads and their barbs resulting in an increased effect. Consider now a patient, who requires a facial lift, there are further factors which ensure efficacy and longevity of the results (barb length, angle, spatial distribution and direction of barbs or cones, resorption time and the collagen-stimulating ability of the thread) (8).

The barbs must have a length that enables them to hook onto the skin tissue and maintain the lift required. If they are too long, then they become too flexible and incapable of lifting the facial tissue. On the other hand, if the barbs are too short, they will not be able to hook onto the facial tissue in the first instance. Furthermore, we need to consider how densely the barbs are placed along the thread length. Threads with a low barb density will not be able to lift the same amount of tissue as threads with a high barb density and therefore will not result in the desired facial lift. In addition, low barb density threads will be less effective at lifting larger volumes of tissue or heavier tissue and restrict the practitioner to working only with small amounts of soft tissue. Of course, a thread must have smooth areas that are barb-free to ensure there is adequate anchoring and to avoid any puckering of the skin. (9).

The angles of the barbs also have a place in how much hold is achieved. If the angle is too small then the lift will be weak, conversely, if the angle is too big the barb may dig into the thread causing it to break. The manufacturing process for some threads can result in the barbs actually digging into the thread, reducing its thickness or gauge in areas. Ideally, the length of the base of the barb should be equal to the thickness of the thread. The spatial distribution of the barbs along the thread will also vary and the more contact there is between the barbs and the facial tissue, the better the hold. Some threads have barbs at different angles in order to achieve a 360° lift; some have cones to maximize tissue contact, while others have all the barbs lined up in one line only. (10).

Threads can come as either mono-directional or bi-directional. To achieve effective lifting of facial tissue the bi-directional threads are preferred as they provide immediate anchoring to the tissue and the thread cannot move either way due to the two-way direction of the barbs. Some mono-directional threads are anchored on both ends at fixed points to enhance stability. The final consideration to make is how long the thread will last in the tissue. PDO threads will stay in the tissue for around 6 months, PLA threads around 12 months, and PCA threads will stay in the tissue for 12-15 months. The longer the thread lasts the more collagen is stimulated and therefore the result is much better and longer lasting. PDO and PLA threads cause fibrosis in the surrounding area and create type 1 collagen. PCA threads stimulate the production of type 1 and 3 collagen which helps to improve the condition of the skin giving a youthful appearance (11).

Which thread to use for which patient? the age of the patient, the treatment area and what trying to achieve. PDO threads are better at repositioning and revitalizing tissue but not for providing lift so would be suited more to younger patients. PLA threads provide some lifting, but again would be suitable for patients who only require a small amount of tissue lift. PCA threads provide more lift and are more suitable for patients who require a small to moderate amount of lift. Other factors that have an effect on the desired results are the technique used to insert the threads and the positioning of the threads (Figure 1) (12).
In summary, each thread type has a place and selecting the right thread for the right patient is vital to achieve the desired outcome as well as managing the patient’s expectations. Good skin is essential as response to the treatment relies on the threads to tighten over the lifted area. Patients with thin skin may have more chances of sutures showing, rippling effect and bruising. Threads lifts are not suitable for patients with excessively saggy skin. Threads may not be suitable if the skin is very aged, thick or damaged, but still it is important to remember that thread lift, especially PCA, represents an option for those who cannot tolerate surgical lifting or narcosis. Patients with good soft tissue volume, less facial fat and a small amount of skin to be lifted will benefit the most from thread lifts. For patients who desire a lifting and/or revitalization effect, thread lifting is a minimally invasive technique which is well-tolerated. The procedure is quick and mostly pain free, although the outcome and final results are dependent on the qualifications discussed above. There will be patients for whom surgical lifting will be a more suitable option and most importantly, thread lifts are not designed to replace surgical lifting (Table 1). (13).

Table 1 Summarizing the different threads (12).
Spiral 3-D multi-direction 2-0 thickness barbed threads (cog threads) give an immediate mechanical lift and the lift will continue to take place via fibrosis and tissue contraction over the next three to four months—an instant lift as well as a delayed lift. Plain mono threads can't give an instant mechanical lift. The plain mono threads inserted into the dermis or sub-cutaneous tissue result in neo-collagenesis and neo-vascularisation. In the adipose tissue, the threads cause a minor degree of lipolysis, and when inserted into the muscle the effect is muscle relaxation (mechanotransduction—acupuncture effect). If loss of muscle function is not desired (botulinum toxin type A effect) then plain mono threads can be inserted into the muscle, for example into the masseters or gastrocnemius muscles. In Korea and the Far East, it's very popular to decrease the calf muscle (gastrocnemius muscle) for cosmetic reasons. In order to reach the desired effect, too much botulinum toxin type A may be required rendering the patient unable to walk normally, especially when wearing high heeled shoes.

By using threads, or a combination of threads and botulinum toxin type A, muscle function is preserved. Mechanotransduction forms the basis of how acupuncture can lead to new collagen regeneration. It is the ability of the cell to sense, process and respond to mechanical stimuli. If one inserts the needle into subcutaneous tissue and twists it twice, a cellular activation process takes place. After the rotations, the fibroblasts around the needle become activated resulting in neo-collagenesis. In the Far East, there are many clinics that perform facial acupuncture facelifts. However, repeated acupuncture needling sessions are required.

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<table>
<thead>
<tr>
<th>Thread type</th>
<th>Rejuvenation</th>
<th>Mild lift</th>
<th>Mild to moderate lift</th>
<th>Moderate lift</th>
<th>Longevity</th>
</tr>
</thead>
<tbody>
<tr>
<td>PDO Smooth</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>6 months</td>
</tr>
<tr>
<td>PDO Cog/Screw</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>6 months</td>
</tr>
<tr>
<td>PLA</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>12 months</td>
</tr>
<tr>
<td>PCA</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>12-15 months</td>
</tr>
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</table>
No conclusive consensus is available with respect to the optimal number of threads in thread augmentation. 2-4 folded barbed PDO threads was inserted for more shallow wrinkles and 3-6 threads for deeper wrinkles in an overlapping manner per 3-4 cm length of the static wrinkle (14).

Deep static wrinkles can be a troublesome matter to both patients and dermatologists. “Solid fillers” (barbed PDO threads in a folded configuration) may be a great treatment option for these wrinkles on the upper face. Although effective, this technique does not prevent the re-appearance of wrinkles with the passing of time. Thread augmentation with barbed PDO threads may be repeated as the aging process continues, either alone or as a complementary procedure to conventional therapies (14).

Studies on barbed PDO suture procedures now in vogue are notoriously lacking. The fundamental principles of thread augmentation presented here stimulate imaginative variations which will further enhance the technique (14).

REFERENCES