Outcomes of Polydioxanone Knotless Thread Lifting for Facial Rejuvenation

Dong Hye Suh, MD, PhD,* Hee Won Jang, MD,† Sang Jun Lee, MD, PhD,* Won Seok Lee, MD,‡ and Hwa Jung Ryu, MD, PhD†

BACKGROUND Thread lifting is a minimally invasive technique for facial rejuvenation. Various devices for thread lifting using polydioxanone (PDO) are popular in aesthetic clinics in Korea, but there have been a few studies regarding its use.

OBJECTIVE To describe PDO thread and techniques adopted to counteract the descent and laxity of the face.

METHODS A retrospective chart review was conducted over a 24-month period. A total of 31 thread lifting procedures were performed. On each side, 5 bidirectional cog threads were used in the procedure for the flabby skin of the nasolabial folds. And, the procedure was performed on the marionette line using 2 twin threads.

RESULTS In most patients (87%), the results obtained were considered satisfactory. Consensus ratings by 2 physicians found that objective outcomes were divided among "excellent," "good," "fair," and "poor." Texture wise, the outcome ratings were 13 as excellent and 9 as good. Lifting wise, ratings were 11 as excellent and 6 as good. The incidence of complications was low and not serious.

CONCLUSION Facial rejuvenation using PDO thread is a safe and effective procedure associated with only minor complications when performed on patients with modest face sagging, fine wrinkles, and marked facial pores.

The authors have indicated no significant interest with commercial supporters.

The process of aging changes the shape, texture, and color of the face. Facial shape is mainly transformed by uneven descent and laxity of the skin and soft tissues. Texture is primarily determined by fine wrinkles and pores of the skin.[1,2]

Recently, there has been a growing trend for patients to pursue minimally invasive treatments with reduced risk of side effects and downtime to correct wrinkles and laxity.[3] A number of procedures have been tried over the past few decades to improve the appearance of a slack face without surgery.[4]

The evolution of thread lifting techniques and their application in the field of aesthetic procedure is now in its third decade.[5] Since Sulamanidze proposed procedures for lifting and rejuvenating facial tissues by means of Aptos threads in 1998, various techniques have been introduced, including Woffles thread lifting, Waptos suture lifting, Isse unidirectional barbed threads lifting, and silhouette lifting.[2,6–8] However, some patients dislike the idea of insertion of nonabsorbable threads that remain permanently in the facial soft tissue. For that reason, new, absorbable, barbed suture designs have become available.[5,9]

**Department of Dermatology, Arumdaun Nara Dermatologic Clinic, Seoul, Republic of Korea; †Department of Dermatology, Korea University College of Medicine, Seoul, Republic of Korea; ‡Department of Plastic Surgery, Gold Plastic Surgical Clinic, Seoul, Republic of Korea*

Supported by a Korea University Grant.

ISSN: 1076-0512 • Dermatol Surg 2015;41:720–725 • DOI: 10.1097/DSS.0000000000000368

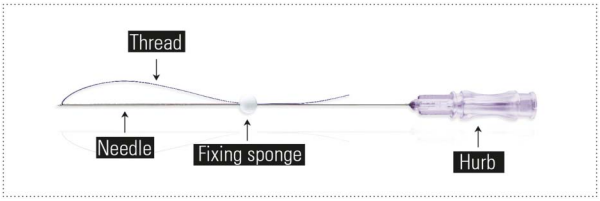

Figure 1. Schematic figure of knotless PDO thread device.

In this study, the authors analyzed a new absorbable lifting device using polydioxanone (PDO). The aim of this study was to describe the efficacy and safety of PDO knotless thread lifting for facial rejuvenation.

Materials and Methods

A retrospective chart review was performed for patients who underwent thread lifting with PDO from April 2012 to March 2014 in Arumdaun Nara Dermatologic Clinic and Gold Plastic Surgical Clinic in Korea. The authors reviewed gender, age, and preoperative and postoperative clinical digital photographs. The results were assessed objectively using serial digital photography and subjectively according to patient self-evaluation. The principles of the 1975 Declaration of Helsinki were followed.

For the objective assessment, 2 physicians not involved in the procedures reviewed the outcomes based on serial digital photography. The outcomes were divided among "excellent," "good," "fair," and "poor." The patients were followed after thread lifting, and their level of satisfaction was self-evaluated according to the scale of "excellent," "good," and "unsatisfied." All statistical analyses were conducted using PASW version 18.0 (IBM, Armonk, NY). Descriptive statistics are shown as both numbers and percentages of patients or as mean values and standard deviations. Ratings of skin texture improvement and lifting were compared by the Mann–Whitney *U* test.

Polydioxanone Threads

A schematic figure of the knotless PDO thread device is presented in Figure 1. Polydioxanone threads for facial rejuvenation can be categorized into 3 different types. Mono PDO thread is monofilament, nonbarbed, and thin (0.07–0.15 mm). Spring or twin thread, made from a twined single monofilament or 2 monofilaments braided, is more tensile than mono PDO thread. Cog PDO thread has barbs, which cling to tissues for lifting effects when inserted. Depending on the direction of the spikes, cog PDO thread is categorized as unidirectional, bidirectional, or multidirectional (Figure 2).

The thread, when inserted to a needle, forms a V-shape with an inner half inserted in the caliber

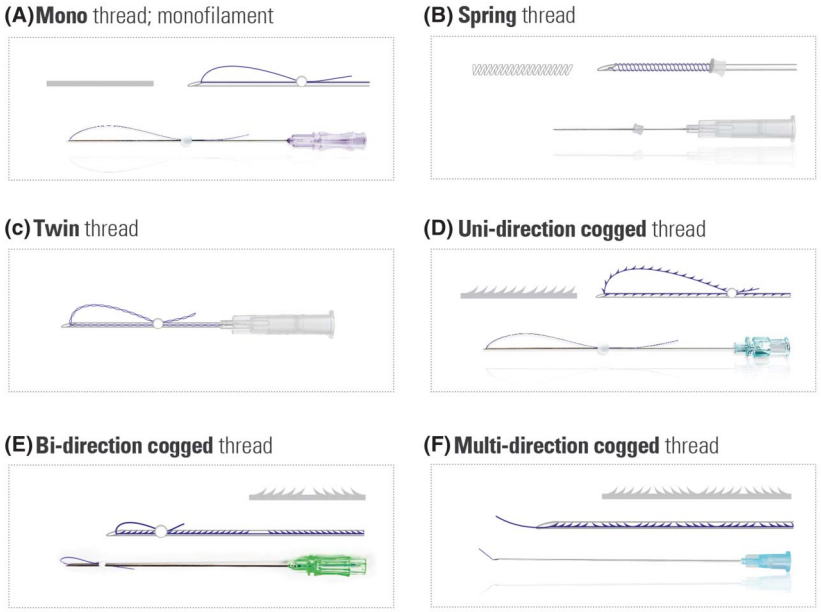

Figure 2. Various knotless PDO thread devices. (A) Mono thread, (B) Spring thread, (C) Twin thread, (D) Uni-direction cogged thread, (E) Bi-direaction cogged thread, and (F) Multi-direction cogged thread.

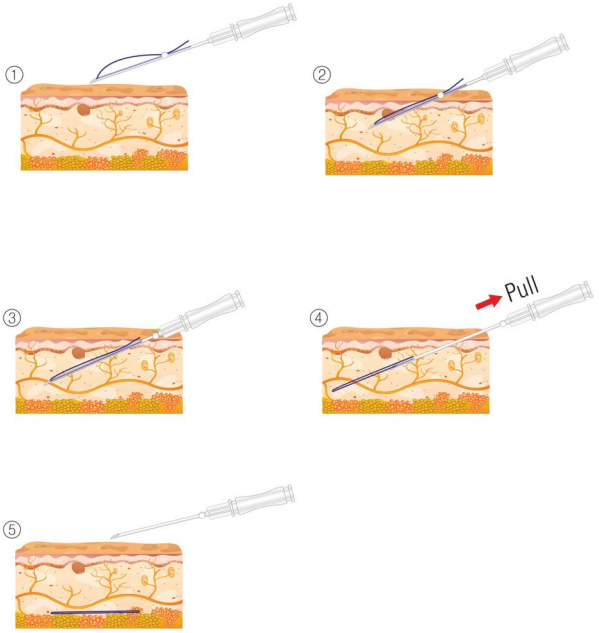

Figure 3. A diagrammatic representation of the actual passage of the threads through the skin. After insertion of the needle, removal of the needle alone results in the thread remaining intact in the tissue.

of the needle and the other half on the outside. After insertion of the needle or cannula, removal of the needle or cannula alone results in the thread remaining intact in the tissue (Figure 3). Needle thicknesses of 18 to 31 gauge and threads with variable length and thickness are available. Appropriate thread length was selected depending on the skin length of the insertion area. Combination of cog and twin threads was used for lifting and rejuvenating purposes in all patients.

Procedure

EMLA cream (AstraZeneca, Alderley Park, United Kingdom) was applied on the affected area for 1 hour before the procedure. The procedure areas were covered with Betadine. Local anesthetic nerve block was performed with 2% lidocaine with epinephrine (1:100,000) (Yuhan, Seoul, Korea).

The procedure site was selected to follow the thread insertion line depending on the patient's wrinkle status. The patient's skin, facial framework, and age were accounted for in designing the procedure, which was generally against the vector of sagging skin.

First, 5 points were made according to the nasolabial fold, and then 2 points were made along the hair line. A straight line was drawn from the edge of the lips to below the ear lobule (Figure 4). Then, they inserted 3.0 bidirectional cog threads on the nasolabial folds according to the straight line. Five threads were inserted subcutaneously on each cheek, with the vector direction against the sagging nasolabial folds. On each side, additional 2 twin threads were inserted lateral to the marionette line, parallel to the mandibular border.

To minimize edema and bruising, ice packs were applied. Oral cephalosporin was given up to 5 days after the procedure. Within the first 3 weeks after the procedure, abrupt actions and big movements of the perioral muscles such as yawning and laughing were prohibited, as was facial massage. Patients were encouraged to sleep in a supine position.

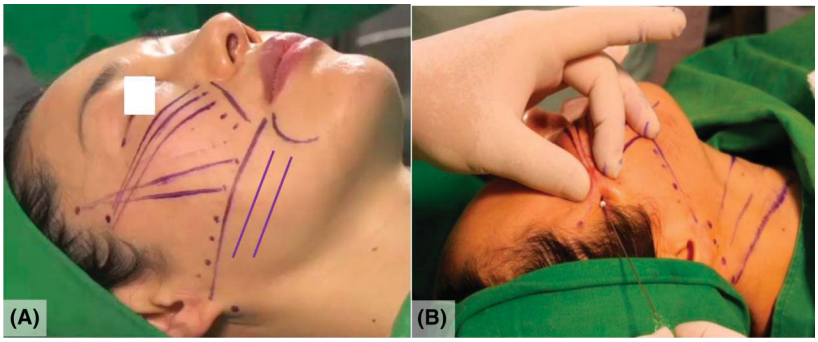

Figure 4. Basic guidelines for knotless PDO thread technique. First, 5 points were made according to the nasolabial fold, and then 2 points were made along the hair line. A straight line was drawn from the edge of the lips to below the ear lobule (A). Then, they inserted bidirectional cog threads on the nasolabial folds according to the straight line. Additional 2 twin threads were inserted lateral to the marionette line, parallel to the mandibular border (B).

Results

Patient clinical characteristics and outcomes are presented in Table 1. A total of 31 patients underwent knotless thread lifting using PDO over a 2-year period. Four were males and the rest were females, with an average age of 44.13 ± 11.02 years. The follow-up period was 24 weeks. In 27 patients (87%), the self-evaluated result was considered satisfactory, including 19 patients (61%) with excellent and 8 (21%) with good results. The result was considered unsatisfactory for the remaining 4 patients (13%). Texture improvement was classified as excellent for 13 (41.9%), good for 9 (29.0%), fair for 8 (25.8%), and poor for 1 (3.2%) patient(s). Lifting was evaluated as excellent for 11 (35.5%), good for 6 (19.4%), fair for 5 (16.1%), and poor for 9 (29.0%) patients. Polydioxanone thread lifting was better for skin texture improvement than for lifting, although there was no statistically significant difference ($p = .139$) (Figure 5).

The most frequent complication was bruising, which happened in 29 patients (93.5%). Mild postprocedure swelling was observed in 28 patients (90.3%). Mild asymmetry was observed in 2 patients (6.5%). These side effects lasted for a maximum of 2 weeks and did not warrant treatment.

TABLE 1. Postoperative Outcomes in Terms of Physician Assessment and Patient Satisfaction

			Physician Assessment		
Patient no.	*Sex*	*Age, yrs*	*Texture Improvement*	*Lifting*	*Patient Satisfaction*
1	F	42	Excellent	Excellent	Excellent
2	F	57	Excellent	Excellent	Excellent
3	M	49	Excellent	Excellent	Excellent
4	M	53	Excellent	Good	Excellent
5	F	55	Excellent	Excellent	Excellent
6	M	62	Excellent	Excellent	Excellent
7	F	60	Excellent	Excellent	Excellent
8	F	52	Fair	Fair	Good
9	F	49	Good	Fair	Good
10	F	34	Fair	Poor	Good
11	F	32	Poor	Poor	Unsatisfied
12	F	42	Fair	Poor	Good
13	F	32	Good	Good	Excellent
14	F	54	Fair	Poor	Unsatisfied
15	F	38	Fair	Poor	Good
16	F	24	Good	Good	Excellent
17	F	57	Excellent	Excellent	Excellent
18	F	54	Excellent	Good	Excellent
19	F	30	Fair	Poor	Unsatisfied
20	F	34	Fair	Poor	Good
21	M	43	Good	Excellent	Excellent
22	F	24	Good	Fair	Good
23	F	53	Good	Fair	Good
24	F	45	Good	Excellent	Excellent
25	F	23	Excellent	Excellent	Excellent
26	F	47	Good	Poor	Excellent
27	F	41	Fair	Poor	Unsatisfied
28	F	37	Good	Good	Excellent
29	F	45	Excellent	Excellent	Excellent
30	F	47	Excellent	Good	Excellent
31	F	53	Excellent	Fair	Excellent

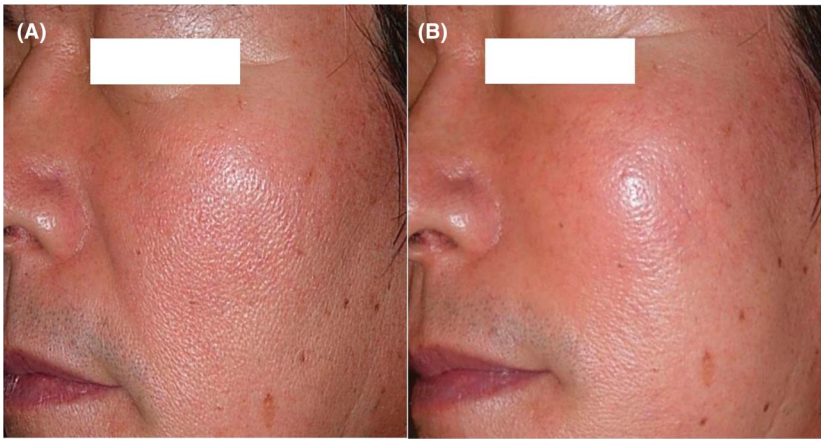

Figure 5. Preoperative and postoperative clinical photograph of a 53-year-old male patient: (A) initial; (B) 6-month follow-up.

Discussion

In the late 1990s, Dr. Sulamanidze inserted bidirectional barbed sutures, manufactured with a nonabsorbable polymer (polypropylene), into the subcutaneous plane of the face.[2] The possible complications of a nonabsorbable suture are palpation, migration, extrusion, and abnormal facial expression on animation.[5] Some patients express concern about the permanent presence of nonabsorbable threads in their facial tissue. For that reasons, more recently, absorbable barbed suture designs have become available.

Nowadays, various knotless thread lifting devices using PDO are popular in aesthetic clinics in Korea. The thread forms a V-shape with portions residing outside the needle/cannula and the other half inside the caliber. After inserting the needle or cannula, simply removing the needle or cannula results in the thread fixation inside the skin without anchorage or knots. This advantage facilitates quick and simple procedures.

Polydioxanone threads take about 6 months to be absorbed, longer than both Vicryl and Dexon. Accordingly, this thread has been used for wounds that require prolonged tensile strength. Given its monofilamentous form, PDO thread is less likely to harbor bacteria.[10] Ruff[11] suggested that PDO, a very slowly absorbed polymer, is sufficient to lift intact tissue satisfactorily with minimal concern about long-term adverse effects. The review of cases in this study found that PDO thread is safe and effective for facial rejuvenation.

Jang and colleagues[12] showed in rats that myofibroblasts around cog threads placed under the skin play a role in fibrous tissue contracture 4 weeks after thread insertion. According to a histological evaluation of absorbable thread lift, a homogeneous fibrous capsule forms around the thread, preserving the traction and compactness of tissues. The dermal papillae have a greater thickness, indicating growth of the interstitial collagen component.[9] The improvements in fine wrinkles and marked pores observed in the patients could be explained by such changes in the dermis. Patient satisfaction and objective assessments indicated higher scores in texture improvement than lifting. Although the cogs were assumed to have lifting effect, it was not as powerful as that of the anchoring thread because of the lack of strong fixation. Further studies are needed to evaluate dermal remodeling by absorbable threads. The most common side effects the authors observed were mild bruising and edema. Erythema usually disappears within a few days. Facial asymmetry may persist for 1 to 2 weeks. The face usually becomes symmetric as time passes, so there is no need to rush for early corrections. Skin dimpling is a troublesome side effect, although it did not occur in this study. If thread is inserted too superficially, the dimpling can occur at the entry point of the thread. Skin rippling can persist for a long period, so inserting the thread at a proper depth is important. Infection,

scar tissue formation, and migration or total extrusion of the thread can occur.

The most important limitation of this procedure is that it is only indicated for a modest degree of facial soft tissue laxity. Paul[5] discussed the effect of selecting patients through experience in midface lifting using absorbable bidirectional barbed sutures. The most favorable anatomic characteristics for absorbable thread lifting are low body mass index, minimal fullness to the soft tissues, strong underlying bony projections to support the elevated tissue, and good skin quality. In the authors' experience, obesity with thick soft tissue results in poor outcomes. Therefore, appropriate patient selection is necessary for optimal outcomes. Insertion of 1 to 3 additional cog threads longitudinal to the cheek is effective for severely saggy skin. For additional marionette lines and chin lift, the use of an extra 3 to 5 cog threads perpendicular to the chin line gives more favorable results.

In conclusion, the technique using PDO thread did not require general anesthesia and avoided scarring, as an incision was not needed. The procedure was effective for uneven facial textures, slack midface, and minimal to moderate jowls in selected patients. The incidence of complications was low and not serious. Aesthetic procedures using PDO thread are a safe method for facial rejuvenation and lifting. Further studies are needed to optimize results and develop better methods.

References

1. Nkengne A, Bertin C. Aging and facial changes—documenting clinical signs, part 1: clinical changes of the aging face. Skinmed 2013;11:281–6.
2. Sulamanidze M, Sulamanidze G. APTOS suture lifting methods: 10 years of experience. Clinics in Plastic Surgery 2009;36:281–306.
3. Atiyeh BS, Dibo SA, Costagliola M, Hayek SN. Barbed sutures "lunch time" lifting: evidence-based efficacy. J Cosmet Dermatol 2010;9:132–41.
4. Rachel JD, Lack EB, Larson B. Incidence of complications and early recurrence in 29 patients after facial rejuvenation with barbed suture lifting. Dermatol Surg 2010;36:348–54.
5. Paul MD. Barbed sutures in aesthetic plastic surgery: evolution of thought and process. Aesthet Surg J 2013;33:17S–31S.
6. Isse NG, Fodor PB. Elevating the midface with barbed polypropylene sutures. Aesthet Surg J 2005;25:301–3.
7. Wu WT. Barbed sutures in facial rejuvenation. Aesthet Surg J 2004;24:582–7.
8. Park TH, Seo SW, Whang KW. Facial rejuvenation with fine-barbed threads: the simple Miz lift. Aesthetic Plast Surg 2014;38:69–74.
9. Savoia A, Accardo C, Vannini F, Di PB, et al. Outcomes in thread lift for facial rejuvenation: a study performed with happy lift revitalizing. Dermatol Ther (Heidelb) 2014;4:103–14.
10. Tajirian AL, Goldberg DJ. A review of sutures and other skin closure materials. J Cosmet Laser Ther 2010;12:296–302.
11. Ruff G. Technique and uses for absorbable barbed sutures. Aesthet Surg J 2006;26:620–8.
12. Jang HJ, Lee WS, Hwang K, et al. Effect of cog threads under rat skin. Dermatol Surg 2005;31:1639–43.

Address correspondence and reprint requests to: Hwa Jung Ryu, MD, PhD, Department of Dermatology, Korea University Ansan Hospital, College of Medicine, Korea University, 516 Gojan-dong, Ansan, Gyeonggi-do 425-707, Korea, or e-mail: dermhj@naver.com

MedCrave
Step into the World of Research

Journal of Dermatology & Cosmetology

Hanging by a Thread: Choosing the Right Thread for the Right Patient

Keywords: Surgery; Polydioxanone; Polylactic acid; Orthopaedic; Polycaprolactone; Hyaluronic acid

Abbreviations: PDO: Polydioxanone; PLA: Polylactic Acid; PCA: Polycaprolactone

Mini Review

Volume 1 Issue 4 - 2017

Vincent Wong*, Rafiq N, Kalyan R, Hsenriksen A and Funner R
Derma Clinic, London

***Corresponding author:** Vincent Wong, Derma Clinic, London, Tel: 0207 299 0380;
Email: info@drvincentwong.com

Received: May 15, 2017 | **Published:** December 05, 2017

Mini Review

Ageing causes loss of facial fat, especially around the cheeks, the eye area, the jowls and the neck. Accompanying this is skin ageing where the elastic fibers in the skin become thinner resulting in loss of facial elasticity? The two processes result in a longer face and 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 [1].

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 [2]. 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.

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.

PCA threads are the newest threads and are bio-absorbable, monofilament suspension threads of synthetic origin (caprolactone) [3]. 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.

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 [4]. 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 [5]. 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 [6,7]. 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).

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.

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 360^0 lift; some have cones to maximize tissue contact, while others have all the barbs lined up in one line only.

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 [8]. 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.

How do we decide which thread to use for which patient? Ultimately we have to look at the age of the patient, the treatment area and what we are 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 [9] (Figure 1).

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 [10]. 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, we must remember that thread lifts are not designed to replace surgical lifting (Table 1).

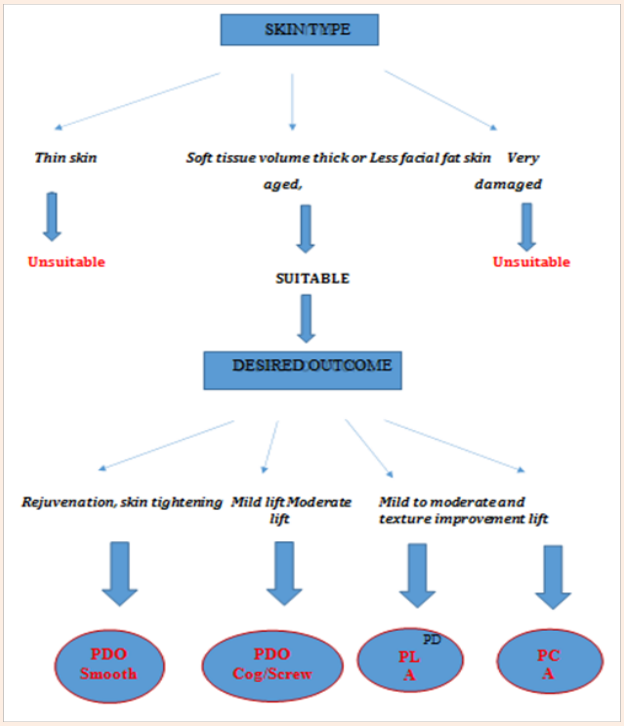

Figure 1: Decision tree to select the right thread for the right patient.

Table 1: Summarizing the different threads.

Thread Type	Rejuvenation	Mild Lift	Mild to Moderate Lift	Moderate Lift	Longevity
PDO	X				6 months
Smooth					
PDO	X	X			6 months
Cog/Screw					
PLA	X		X		12 months
PCA	X			X	12-15 months

Citation: Wong V, Rafiq N, Kalyan R, Hsenriksen A, Funner R (2017) Hanging by a Thread: Choosing the Right Thread for the Right Patient. J Dermat Cosmetol 1(4): 00021. DOI: 10.15406/jdc.2017.01.00021

Acknowledgment

None.

Conflict of Interest

None.

References

1. Khazanchi R, Aggarwal A, Johar M (2007) Anatomy of ageing face. Indian J Plast Surg 40(2): 223-229.
2. Shimizu Y, Terase K (2013) Thread Lift with Absorbable Monofilament Threads. J Japan Soc Aesthetic Plast Surg 35(2): 1-12.
3. Savoia A, Accardo C, Vannini F, Di P B, Baldo A (2014) Outcomes in Thread Lift for Facial Rejuvenation: A Study Performed with Happy Lift™ Revitalizing. Dermatology and Therapy 4(1): 103-114.
4. Tonks S (2015) Understanding Thread Lifting. Aesthetics.
5. Dancey E (2014) New generation absorbable threads. Aesthetics.
6. Wu WT (2004) Barbed sutures in facial rejuvenation. Aesthet Surg J 24(6): 582-587.
7. De Lorenzi C (2006) Barbed sutures: Rationale and technique. Aesthet Surg J 26(2): 223-229.
8. Kalra R (2008) Use of barbed threads in facial rejuvenation. Indian Journal of Plastic Surgery 41(Suppl): S93-S100.
9. Mian I (2017) PDO Threadlifting. Aesthetics.
10. Paul MD (2008) Complications of barbed sutures. Aesthet Plast Surg 32(1): 149.

Citation: Wong V, Rafiq N, Kalyan R, Hsenriksen A, Funner R (2017) Hanging by a Thread: Choosing the Right Thread for the Right Patient. J Dermat Cosmetol 1(4): 00021. DOI: 10.15406/jdc.2017.01.00021

Novel Polydioxanone Multifilament Scaffold Device for Tissue Regeneration

Hyuk Kim, MS,* Il-Hong Bae, MS,* Hyun-Ju Ko, MS,* Jin-Kyu Choi, MS,†
Young-Ho Park, PhD,* and Won-Seok Park, PhD*

BACKGROUND Facial aging is the result of intrinsic and extrinsic factors that lead to gradual reduction of dermal extracellular components and skin elasticity and wrinkle formation. A novel stent-shaped biodegradable and biocompatible scaffold device braided with absorbable polydioxanone (PDO) multifilaments was recently marketed for tissue suturing and augmentation.

OBJECTIVE To explore tissue regeneration profiles following implantation of the stent-shaped hollow scaffold in rats and mini-pigs.

MATERIALS AND METHODS The scaffold device was implanted under the panniculus carnosus of rat dorsal skin and in the subcutaneous layer of mini-pig dorsal skin. Tissue samples were harvested and histologically evaluated after 3 days and 1, 2, 4, and 12 weeks for rats and after 1, 2, 4, 8, and 12 weeks for mini-pigs.

RESULTS Type III collagen was slowly replaced by Type I collagen in the scaffold. Cells from the surrounding tissue infiltrated the hollow space of the scaffold, which induced de novo tissue regeneration in this space.

CONCLUSION The novel stent-shaped scaffold used here may be useful for stimulated tissue remodeling of aged skin, collagen synthesis, and partial restoration of dermal matrix components. The cosmetic purpose of this novel soft tissue augmentation device should be clinically investigated in long-term studies.

The authors have indicated no significant interest with commercial supporters.

As humans age, wrinkles on the face or body deepen and make people look older than they are chronologically. Fine and deep wrinkles have many intrinsic and extrinsic causes,[1] including lifestyle habits and behaviors, such as tanning, smoking, and sleeping positions, which can increase the risk of premature skin aging.

Several methods are available for non-surgical correction of wrinkles. Botulinum toxin Type A or B injections are one of the most common and effective approaches for wrinkle correction. However, it is limited by incomplete alleviation of wrinkles caused by underlying muscle contraction and its short-term (3–5 months) effects. Use of hyaluronic acid-based injectable fillers is another safe and effective method for correction of wrinkles caused by loss of collagen and skin elasticity, but like botulinum toxin injections, its relatively short-term efficacy (12–18 months) is a limitation. Additionally, the hyaluronic acid tends to migrate toward the direction of muscle contraction after injection.[2]

Polydioxanone (PDO) is a reabsorbable polymer that remains in position for a considerable time (approximately 180–230 days).[3] Biodegradable PDO has been used mainly in laparotomy sutures and esophageal stents, but more recently, PDO monofilaments have been implanted to cosmetically enhance the skin.[4] Cosmetic PDO monofilaments can be used for minimally invasive lifting of various types of wrinkles on the neck and face, including sagging

**Amorepacific Corp. R&D Unit, Medical Beauty Division, Yongin-si, Republic of Korea; †Aestura Corp. Analysis Research Team, Ansung-si, Republic of Korea*

Hyuk Kim and Il-Hong Bae equally contributed as first authors.

ISSN: 1076-0512 • Dermatol Surg 2016;42:63–67 • DOI: 10.1097/DSS.0000000000000585

brows, malar folds, and noticeable nasolabial and marionette folds. Absorption of the PDO threads accelerates the production of new dermal matrix.

Recently, we successfully developed a novel tissue regeneration system comprising a stent-shaped hollow scaffold device braided with multiple PDO filaments that remain secure after implantation into the subcutaneous layer. This stent-shaped structure, which is designed to lift wrinkles, creates a hollow space in which newly formed collagen can accumulate, in addition to collagen deposition on the exterior of the implant. In the present study, we explored the in vivo efficacy of this new device in rats and mini-pigs.

Materials and Methods

Morphology

The absorbable stent-shaped hollow multifilament device used in this study was originally designed and manufactured by Metabio Med (Osong, South Korea) and is marketed as Retense (Aestura; Seoul, South Korea). This scaffold comprises a thin, long mesh tube that penetrates the subcutaneous tissue and through-holes that guide tissue cells surrounding the scaffold into the hollow portion to form fibrous tissue. The through-holes provide lengthwise conduits from the outer surface to the hollow portion of the mesh tube.

The structural features of the device measured using electron microscopy (Figure 1) included the outer diameter, inner diameter of the hollow portion, and through-hole diameter.

Rat Model

Twelve female Sprague-Dawley rats, each weighing 400 g, were purchased from Orient Bio (Gyunggi-do, South Korea). A scaffold was nonsurgically implanted under the panniculus carnosus of the dorsal skin of each rat under isoflurane anesthesia. The distance between the entry and exit points of the scaffold was 50 mm. Three rats were sacrificed at different time points (3 days and 1, 2, 4, and 12 weeks) after scaffold implantation. Skin biopsy specimens, including the scaffold and surrounding tissue, were obtained and subjected to histologic evaluation. Samples were fixed in 10% formalin, embedded in paraffin, processed routinely, sectioned transversely to the thread axis at 4-μm thickness, and stained with hematoxylin and eosin. Replicate sections were stained with Masson's trichrome to examine all types of collagen and Herovici stain to differentiate Types I (purple) and III (blue) collagen. All experimental procedures and protocols were approved by and performed in accordance with the Institutional Animal Care and Use Committee of Aestura Corporation.

Mini-Pig Model

A single 5-month-old female PWG mini-pig (Medi Kinetics, Pyeongtaek, South Korea) weighing approximately 20 kg was used in this part of the experiment.

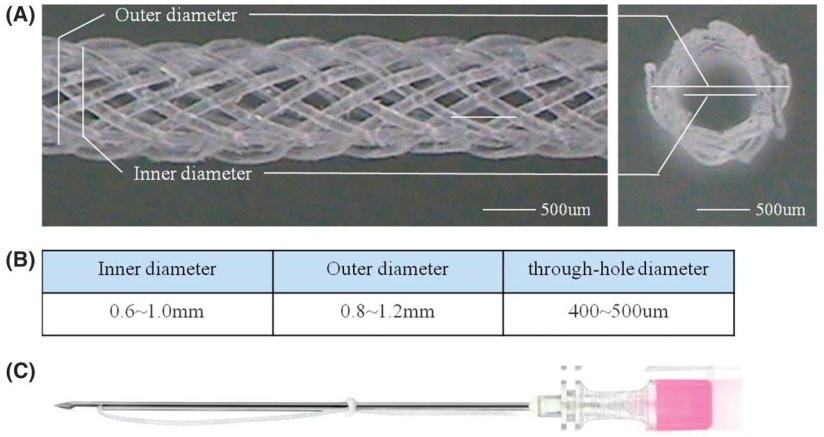

Figure 1. Structure of the stent-shaped hollow scaffold device. (A) Electron microscopic image of the stent-shaped hollow scaffold device. Bar indicates 500 μm. (B) Braided morphological pattern of the scaffold device. (C) Implantation of the scaffold device.

Scaffolds were implanted subcutaneously in the dorsal skin. The distance between the entry and exit points of the scaffold was 50 mm. Skin biopsy specimens were collected at 1, 2, 4, 8, and 12 weeks prior to sacrifice and processed as described above for rats.

Histologic Analysis

Histopathologic analysis was performed using a BX53 calibrated microscope, equipped with a DP72 digital camera and cellSens imaging software (Olympus, Tokyo, Japan). Borders were manually traced for the area of newly generated tissue. Histomorphometric analysis for a given scaffold was conducted by calculating the measured area of collagen neogenesis minus the thread area. Measurements were made on 5 cross-sections, including the proximal and distal ends and the midpoints of each implantation site.

Results

Scaffold Device Measurements

The outer diameter of the scaffold device was approximately 0.8 to 1.2 mm; the inner diameter of the hollow portion was 0.6 to 1.0 mm, and the through-hole diameter ranged between 400 and 500 μm.

Changes in Histologic Findings After Implantation of the Multifilament PDO Scaffold in Rats

On day 3 postimplantation, the structure of the scaffold was almost unchanged. No significant newly formed tissue was noted, but some fibrin and inflammatory cells were seen inside the scaffold. Further, a small amount of Type III collagen was noted around each thread. At 1 week postimplantation, fibroblasts with high cellularity and a moderate amount of collagen (mostly Type III) were observed inside the scaffold. The inner area of the scaffold was 5 times larger than the area on day 3, and the space between threads had widened. After 2 weeks, the collagen density had increased but fibroblast cellularity had decreased. The inner area of the scaffold was 40% less than that at 1 week but 3 times larger than that on day 3 post-implantation. Both Types I and III collagen were observed, and many blood microvessels were seen inside the scaffold with accumulation of newly formed tissue. At 4 weeks postimplantation, the number of fibroblasts had decreased and the mature collagen bundle was thick and organized. The ratio of Type I to Type III collagen had increased, with the central regenerated area comprising mostly Type I collagen and the periphery comprising mostly Type III collagen. The number of microvessels had decreased from that at 2 weeks. After 12 weeks, collagen fibers had formed a dense structure and the amount of Type I collagen in the scaffold had increased significantly. Detailed histologic results are presented in Figure 2.

Changes in Histologic Findings After Implantation of the Multifilament PDO Scaffold in Mini-Pig

At 1 week postimplantation, thick layers of infiltrates comprising inflammatory cells and fibroblasts were present around the scaffold, but no particular structure was seen inside the scaffold. At 2 weeks, the collagen that filled up the interior of the scaffold was entirely of Type III, and fibroblast cellularity seemed low. At 4 weeks, the proportion of Type I collagen had increased while that of Type III collagen had decreased inside the scaffold. Then, at 8 weeks postimplantation, blood microvessels were seen inside the scaffold, and the number of fibroblasts had decreased. Further, the collagen bundles were thicker and more organized than before. The ratio of Type I to Type III collagen had increased, with the central area comprising Type I collagen and the peripheral single filament comprising Type III collagen. Twelve weeks after implantation, the collagen fibers formed a dense structure, accompanied by phenotypic replacement of Type III collagen by Type I collagen. Additionally, stent degradation was observed within the irregularly shaped scaffold structure. Detailed histologic results are presented in Figure 3.

Discussion

Cutaneous aging is a process caused by intrinsic and extrinsic factors associated with many pathologic changes, including gradual reduction of dermal extracellular components, dermal cell functions, and skin elasticity. All these processes ultimately lead to facial ptosis and wrinkles. During the last decade,

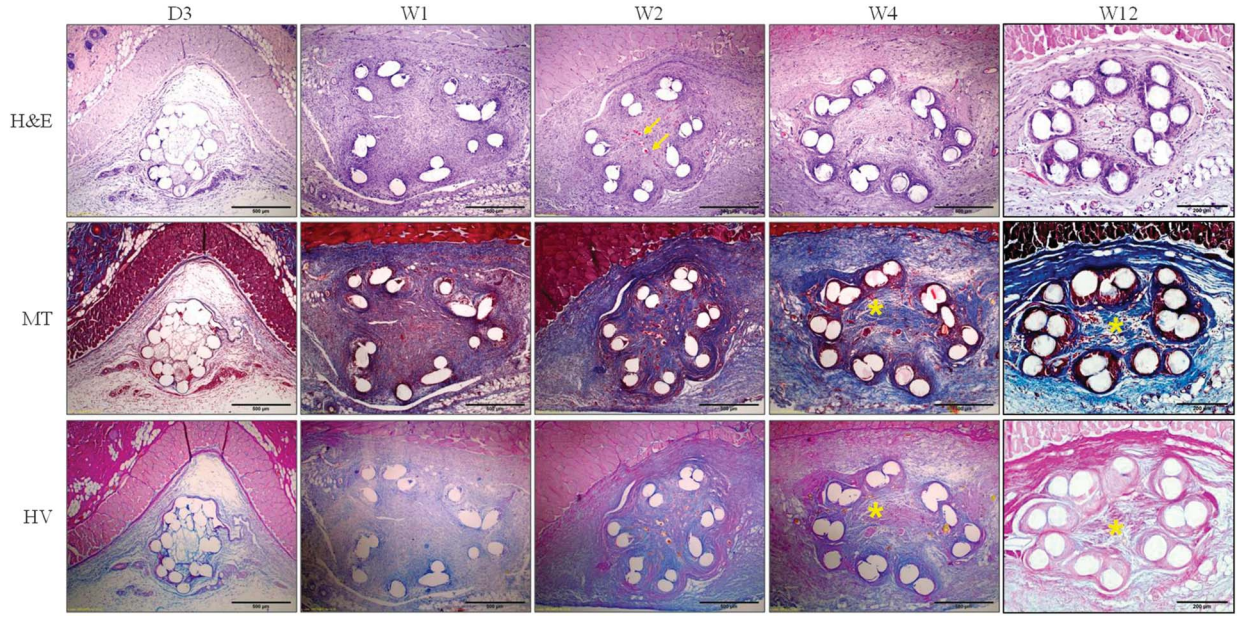

Figure 2. Serial histologic changes in the tissue surrounding the scaffold embedded in the rat dorsal skin. Formation of micro blood vessels (arrow) and bundles of collagen (asterisk) can be seen. Replicate sections of the samples were used for Masson trichrome (MT) staining for all types of collagen and Herovici (HV) staining to differentiate Types I (purple) and III (blue) collagen.

various dermal implants and cosmetic procedures have been developed for wrinkle removal and skin rejuvenation. These include plastic surgical approaches (such as facelifts) as well as nonsurgical and minimally invasive methods (such as botulinum toxin injection, laser therapy, and implantation of lifting threads and soft tissue augmentation fillers).[5–7] These methods are designed to restore diminished skin volume and encourage tissue regeneration via *de novo* collagen synthesis.

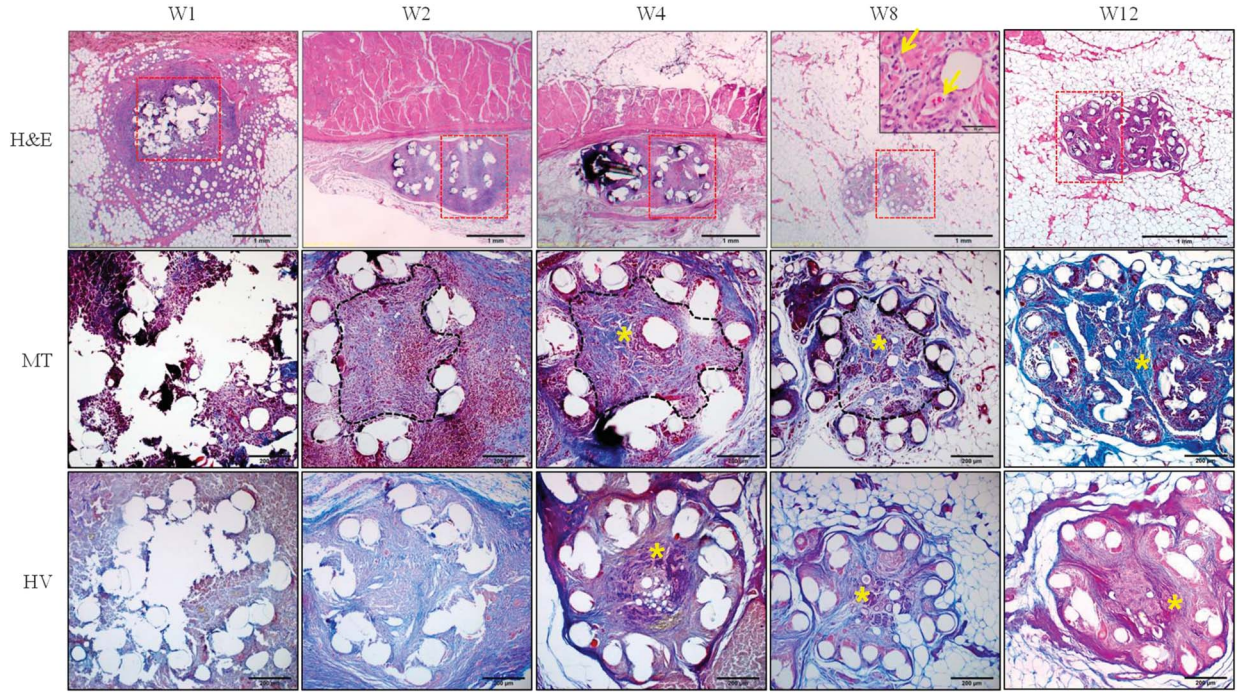

Figure 3. Serial histologic changes in the tissue surrounding the scaffold device implanted in mini-pig dorsal skin, showing formation of micro blood vessels (arrow) and bundles of collagen (asterisk) and an area of newly generated fibrous connective tissue (dotted line). Insets in red squares show MT and HV staining.

Ideal dermal implants should resist physical force and be chemically inert and biocompatible.[8,9] They should also be nonallergenic, nonimmunogenic, noncarcinogenic, nonpyrogenic, and noninflammatory. Metals, ceramics, and polymers have been used as implants in humans. The novel stent-shaped hollow scaffold used in the present study is composed of PDO monofilaments, which are stable and easy to process and induce only mild adverse reactions. PDO is a colorless, crystalline, bioabsorbable polymer that was developed specifically for wound closure sutures. It is derived from the monomer paradioxanone after ring-opening polymerization with heat and application of organometallic catalysts like zirconium acetylacetone, diethyl zinc, and zinc L-lactate ($ZnLac_2$) resulting in a poly(ether–ester).[10] It is typically manufactured as monofilaments for suturing purposes. As an absorbable suture, it has higher flexibility (irrespective of the diameter) and tensile strength, slow absorption rates, and lower inflammatory response rates than both polyglycolic acid (Vicryl; Ethicon, Somerville, NJ) and polylactic acid (Dexon; Covidien, Dublin, Ireland).[11,12] In vivo, PDO is slowly hydrolyzed to 2-hydroxyethoxyacetic monomer, the majority of which is excreted in urine with the rest being eliminated by digestion or exhaled as carbon dioxide in 6 to 8 months.[8]

Type I collagen is the main fibrillar protein responsible for the mechanical properties of newly formed tissue. Although Type III collagen is also a fibrillar collagen found in extensible connective tissues, it is mostly related to fast-growing tissues, particularly in the early stages of tissue regeneration. During remodeling, Type III collagen is replaced by the stronger and tougher Type I collagen, which provides the required strength to support load. In the present study, the ratio of Type I to Type III collagen gradually increased with time, in both the rat and mini-pig models, with Type I collagen eventually replacing Type III collagen entirely. Additionally, abundant newly formed fibrous tissue, including collagen fibers, accumulated inside the scaffold through the surface holes of its mesh-like structure. These findings indicate that the stent-shaped multifilament PDO scaffold used here may sufficiently support and accelerate fibroblast infiltration from the surrounding tissue and induce tissue regeneration in the scaffold interior. Further, the intrinsic mechanical properties of our novel stent-shaped hollow PDO scaffold include recoil force, that is, the scaffold is not deformed by any external force applied to the skin after it is inserted into the subcutaneous layer.

On the basis of our findings, we believe that this novel PDO scaffold could be applicable for various kinds of wrinkles, including deep furrows, by adjusting the diameters of the scaffold, hollow portion, and through-holes. Further, the wrinkle-diminishing effect of this scaffold may last semipermanently because it enables de novo formation of fibrous tissue. However, clinical studies are required to confirm the safety and long-term efficacy of this scaffold for wrinkle correction.

References

1. Baumann L. Skin aging and its treatment. J Pathol 2007;211:241–51.
2. Buck DW II, Alam M, Kim JY. Injectable fillers for facial rejuvenation: a review. J Plast Reconstr Aesthet Surg 2009;62:11–8.
3. Bellón JM, Pérez-López P, Simón-Allue R, Sotomayor S, et al. New suture materials for midline laparotomy closure: an experimental study. BMC Surg 2014;14:70.
4. Stivaros SM, Williams LR, Senger C, Wilbraham L, et al. Woven polydioxanone biodegradable stents: a new treatment option for benign and malignant oesophageal strictures. Eur Radiol 2010;20:1069–72.
5. Barton FE. Facial rejuvenation techniques. Mund Kiefer Gesichtschir 1997;1:328–34.
6. Fagien S. Botox for the treatment of dynamic and hyperkinetic facial lines and furrows: adjunctive use in facial aesthetic surgery. Plast Reconstr Surg 1999;103:701–13.
7. Fagien S, Carruthers JD. A comprehensive review of patient reported satisfaction with botulinum toxin type a for aesthetic procedures. Plast Reconstr Surg 2008;122:1915–25.
8. Molea G, Schonauer F, Bifulco G, D'Angelo D. Comparative study on biocompatibility and absorption times of three absorbable monofilament suture materials. Br J Plast Surg 2000;53:137–41.
9. Kurita M, Matsumoto D, Kato H, Araki J, et al. Tissue reactions to cog structure and pure gold in lifting thread: a histological study in rats. Aesthet Surg J 2011;31:347–51.
10. Boland ED, Coleman BD, Barnes CP, Simpson DG, et al. Electrospinning polydioxanone for biomedical applications. Acta Biomater 2005;1:115–23.
11. Ray JA, Doddi N, Regula D, Williams JA, Melveger A. Polydioxanone (PDS), a novel monofilament synthetic absorbable suture. Surg Gynecol Obstet 1981;153:497–507.
12. Tajirian AL, Goldberg DJ. A review of sutures and other skin closure materials. J Cosmet Laser Ther 2010;12:296–302.

Address correspondence and reprint requests to: Won-Seok Park, Amorepacific Corp. R&D Unit, 1920 Yonggu-daero, Giheung-gu, Yongin-si, Gyeonggi-do, Republic of Korea, or e-mail: wspark@amorepacific.com