Review

Polydioxanone for thread lift in anti-aging medicine: is it still used? A literature review

Ni Nyoman Ayu Laksmi Trimurti[1], *Ni Made Linawati*[1,2], *Dewa Ayu Agus Sri Laksemi*[1,3]

[1]Magister Program in Anti-Aging Medicine, Faculty of Medicine, Universitas Udayana, Denpasar, Bali, Indonesia; [2]Histology Department, Faculty of Medicine, Universitas Udayana, Denpasar, Bali, Indonesia; [3]Paracitology Department, Faculty of Medicine, Universitas Udayana, Denpasar, Bali, Indonesia

Abstract. *Introduction*: Aging is an unavoidable process that affects all living organisms. However, chronological age, that is the number of years of life lived, is not necessarily equivalent to biological age. Biological age refers to the condition and function of a person's body's cells, tissues, and organ systems. The function of cells, tissues, and organ systems will inevitably decline over time, however the rate of decline can be mitigated. Aging will occur in all organs of the body, including the skin. The skin is the largest and outermost organ, and changes are immediately visible when it is affected by the aging process. The most common changes in the skin due to aging are wrinkling, roughness, dryness, and sagging. Anti-aging medicine is a science based on the principle that all aging signs can be prevented and treated so that bodily functions remain optimal despite increasing age, which in turn improves a person's quality of life. Anti-aging medicine encompasses many therapeutic modalities. These modalities can be performed through invasive and non-invasive approaches. One invasive skin treatment that has long been developed and remains popular is the thread lift. *Aim*: This review aimed to re-explore the role of polydioxanone thread in Anti-Aging medicine amidst the many emerging materials. A comprehensive overview and related research studies on polydioxanone thread will be further explored in this review.

Key words: polydioxanone threads, thread lift, aging process, skin aging, anti-aging medicine, facial rejuvenation

Introduction

The aging process is a degenerative process that naturally occurs in all living organisms. "Ageing" typically refers to individuals over the age of 60 years[1,2]. One in six persons worldwide is expected to be 60 years of age or older by 2030. Between 2020 and 2050, there will be a threefold increase in the number of individuals aged 80 years or older, totaling 426 million[2]. As we age, all essential organs begin to lose some function. This partially explains the increased mortality of chronic diseases in old age, known as age-related diseases, such as cardiovascular disease, cancer, and neurodegenerative disorders[3,4]. The aging process is gradual, beginning at around 25 years of age and becoming more apparent with increasing age. Several modifications result from the combination of both endogenous and exogenous factors throughout this process. These factors have a synergistic effect, leading to manifestations of aging in all organs, including the skin[5]. Skin aging is often a major concern because the changes are immediately visible[3,6]. Wrinkles are caused by an increase in skin laxity due to a decrease in the fibroblasts that produce collagen and the supporting vasculature during the aging process. Extrinsically, aging skin is predominantly affected by sunlight exposure, although other factors such as pollution, environment, and lifestyle can lead to the loss of collagen and elastic fibers, which weakens the link between the epidermis and dermis[5].

However, in recent decades, many theories supporting Anti-Aging Medicine have emerged in order to detect, prevent, treat, and reverse age-related dysfunctions, disorders, and diseases early on, anti-aging medicine employs cutting-edge science and medical technology[7]. The paradigm of Anti-Aging Medicine is to prevent aging and restore organ system functions to their youthful state, thereby increasing productivity and quality of life[7,8]. With this principle, many treatments based on Anti-Aging medicine have been developed[8]. One invasive treatment that has been practiced for a long time and remains popular is thread-lifting. Sulamanidze and colleagues initially advocated thread lifting, often referred to as "the lunchtime facelift," in the 1990s[9,10]. Restoring lost volume with thread lift can minimize wrinkles and reduce sagging in the face. One of the key advantages of thread lift is that it can be performed in a clinical setting under local anaesthesia instead of requiring more invasive surgery under general anaesthesia[9,10].

Today, several materials have been developed for thread-lifting, such as polydioxanone (PDO), polycaprolactone (PCL), polylactic acid (PLA), and poly-L-lactic acid (PLLA). However, PDO is the most established and still preferred material due to its mild side effects and easy availability[11]. Many studies on both animals and humans have shown the effects of PDO thread lifts on skin aging. This review aims to explore the role of polydioxanone threads lift on skin aging especially in facial rejuvenation. An understanding of the efficacy, procedure, and complications that might happen on PDO thread implantation is necessary for more precise handling. We looked through research articles, reviews, reports, and other data sources published using search engines PubMed and Google Scholar. The search term used includes research articles focused on the role of PDO thread lift in Anti-aging medicine that was collected from 2017 through 2024 and were used for data collection, by using the term 'polydioxanone threads' alone or in combination such as polydioxanone (PDO) threads, anti-aging, aging process, skin aging, facial rejuvenation.

Aging process

A complicated biological process, aging is impacted by social, environmental, genetic, and epigenetic factors. This process is accompanied by a gradual deterioration in the body's physical capabilities and a higher chance of age-related chronic illnesses including cancer, heart disease, and neurological problems[6,12]. This process is explained by multiple interrelated theories, collectively known as the hallmarks of aging. Nine cellular and molecular hallmarks of aging are divided into three groups: (a) the primary hallmarks, (b) antagonistic hallmarks, and (c) integrative hallmarks. The primary hallmarks that are unquestionably harmful to the cell are loss of proteostasis, telomere attrition, genomic instability, and epigenetic alterations. The second is antagonistic hallmarks, which are advantageous at low levels but harmful at high levels, are deregulated nutrient sensing, cellular senescence, and mitochondrial dysfunction. The third is integrative hallmarks are stem cell depletion and altered intercellular communication that impact tissue homeostasis and function[13,14]. In addition to the hallmark of aging, other risk factors increase the progression of the aging process.

Skin aging

The skin is the body's largest organ in terms of weight and area, and serves as a "*brain on the outside*"—a body sensor[15]. Exogenous or extrinsic factors (chronic light exposure, ultraviolet (UV) exposure, air pollution, ionizing radiation, chemicals, toxins) and endogenous or intrinsic factors (genetic, cellular metabolism, hormone, and metabolic processes) combine to influence the complex biological process of skin aging. By inducing the generation of reactive oxygen species (ROS) and exhibiting progressive damage at all skin levels as well as changes in appearance, particularly on sun-exposed skin regions known as photoaging, these variables work in concert to cause cumulative structural and physiological alterations (Figure 1)[8,15,16]. The decrease in antioxidant defenses with increasing age causes redox imbalance and stimulates the formation of oxidative stress[6,17].

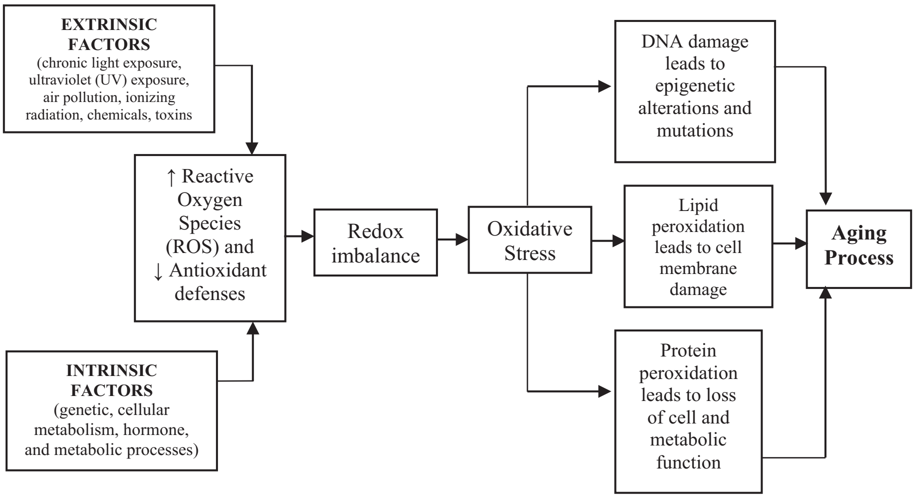

Figure 1. The role of ROS in stimulating oxidative stress and its effect on the aging process

According to research, intrinsic factors account for just 3% of the factors contributing to skin aging, with extrinsic factors being the primary culprit[18]. Intrinsic skin aging is subtle and slow in progression and varies significantly among populations, among people of the same ethnicity, and across different regions of the same individual's body. Intrinsic aging in the skin is influenced by systemic aging as well as declines in collagen formation, fibroblasts, dermal mast cells, and flattening of the dermal-epidermal junction including the loss of rete ridges[12]. Extrinsically aged skin (primarily due to ultraviolet radiation (UVR) exposure) has a sallow complexion, uneven pigmentation, rough texture, coarse wrinkles, and decreased skin elasticity. While UVB primarily reaches the epidermis, which can cause sunburn, tanning, and photo carcinogenesis, deeply penetrating UVA destroys dermal connective tissue and increases the risk of skin cancer[16,19]. The link between chronic exposure to UVR and facial lentigines as a manifestation of skin aging has been strongly linked to an increased risk of basal cell carcinoma, a kind of skin cancer, according to a recent epidemiological study conducted on elderly Caucasian women[20,21]. Table 1 will outline the phenotypic and genotype changes associated with skin aging.

Skin aging prevention and therapy

The majority of anti-aging research throughout the years has focused on the main structural elements of the dermis, such as collagen, elastin, and glycosaminoglycans. The "successful aging" paradigm, which challenges conventional conceptions of aging as a time-related disease, emphasizes health and active living. It is also increasingly associated with decreasing physical symptoms of aging on the body, face, and skin[24]. According to this viewpoint, preventive aesthetic dermatology can contribute to healthy aging by treating or preventing specific cutaneous conditions, most notably skin cancer, and slowing down the aging process of the skin using systemic and local therapeutic techniques. Those methods can be grouped into cosmetic care (such as facial wash, sunscreen, moisturizer, and other daily skincare), systemic approaches (such as a balanced diet, hormone replacement therapy, and antioxidant supplements), and both invasive and non-invasive procedures[24–27].

In the field of dermatology, more invasive treatments and injectables are being used to tighten and renew skin, improve wrinkles, and restore the volume of soft tissue in aging skin[5,27-29]. The demand for invasive dermatological procedures is rapidly increasing.

Table 1. Difference of the Influence of Intrinsic and Extrinsic Factors on Skin Aging

Feature	Intrinsic Factors	Extrinsic Factors	Reference
Phenotype appearance	Fine lines, some skin surface marks being more deeply set, some skin becoming less elastic, and superfluous skin giving the impression of sagging.	Nodular, leathery skin, sallow complexion, uneven yellowish pigmentation, coarse wrinkles, extreme elasticity loss, reddish, and mild creases that increase progressively.	5,16,23
Epidermis layer	Thinner than typical, with reduced cell proliferation and mild irregularities in keratinocyte regularity; typical corneum stratum.	Thick skin with acanthosis and subsequent cell atrophy; high irregularity of basal keratinocytes; The stratum corneum seems dense; rete pegs disappearing.	16,18,23
Dermis layer	Thinner, fibroblasts dwindled, inactive decreased mast cells, elastin fibers exhibited an uneven arrangement, and the quantity and thickness of collagen fibers started to decline. Loss of microvascular.	Excessive creation of elastin fibers in the wrong orientation thickened and quickly worn-out collagen fibers; elastosis, fibroblasts increased; hyperactive mast cells. Solar elastosis. Loss of microvascular, telangiectatic, reduced angiogenic capacity and function.	16,18,22,23
Extracellular matrix	Elastic fiber increased. Bundles thick and discontinuous collagen. Oligosaccharide are degenerated, which in turn influences the ability of skin to retain bound water	Elastic fiber eventually becoming an abnormal mass. Collagen decrease of bundles and fibers.	6,16,18,23

In 2020 there was a 10% decline in traditional surgical treatments but a 5% global increase in less invasive cosmetic procedures[30]. Thread lift is one of the least invasive techniques used to redistribute lost volume and fat, augmentation of the skin, and contouring[31]. The minimally invasive, quick treatment of thread lifting, performed at an outpatient clinic, is gaining appeal among patients and physicians alike[32]. Platelet-rich plasma (PRP), facial filler therapy, neuromodulator treatments, or surgical treatments are some examples of face cosmetic procedures that can be combined or substituted with thread lift sutures for facial augmentation[31–33].

Thread lift

Employing medical threads to raise sagging features is not a new concept. Thread lifting techniques have been created for a variety of uses, including sub-mental lifting, neck lifting, and eyebrow-raising[31]. Thread Lifting has been mainly applied in the mid-face, jawline, lower face, and malar fat pad for the reduction of aesthetic manifestations of ageing.

After the development of thread-lift sutures, their use has progressively expanded among a wide range of cosmetic medical specialists, including plastic surgeons and maxillofacial surgeons, as well as cosmetic physicians, including medical doctors and dentists with specialized training. The primary indication for thread-lift sutures is to raise sagging tissues through a closed, minimally invasive procedure[34]. In the 1990s, Sulamanidze and colleagues came up with a barbed thread method for tightening facial tissues, and later introduced it as anti-ptosis (Aptos) thread, which has subsequently gained international recognition[35]. In 2003, Sulamanidze also created the polypropylene spring-formed thread known as Aptos Springs. Lifting threads can be composed of both absorbable and nonabsorbable materials[36]. In recent years there has been a rise in the use of absorbable thread lifts due to documented issues with nonabsorbable barbed sutures[29]. Currently, absorbable threads made of polydioxanone (PDO), polylactic acid (PLA), and polycaprolactone (PCA) or poly-L-lactic acid (PLLA), and non-absorbable threads made of polypropylene are still available for medical use[11,37]. Despite the paucity of clinical research on the matter, the primary studied benefit of adopting nonabsorbable threads is their long-lasting impact. Utilizing absorbable threads has the benefit of lowering the likelihood of complications[36,38]. The drawback of absorbable threads is that should an issue arise, like an infection, it is impossible to predict or eliminate a long-term consequence. The risk of infection is not thought to differ for soluble and insoluble threads since they are both regarded as foreign entities in the tissue. As a result, there is a greater chance of infection with soluble threads than insoluble ones.

Problems arising following a thread lift procedure are scarce in research and documented clinical experience, regardless of the materials used[39]. These complications include pain, swelling, bleeding, hematoma formation, bruising, and other short-term symptoms; aesthetic concerns, such as irregular facial contours, skin dimpling, and tension; neurosensory sequelae, such as tension, numbness, and pruritus; and damage to surrounding structures, such as parotid glands, facial nerves, and ducts. While the majority of these issues are minor and may resolve on their own or require nonsurgical treatment, others, such as thread exposure, subcutaneous nodule, and infection, may need surgical removal of the threads and debridement[40,41].

Polydioxanone (PDO) Thread lift

Thread lifting using polydioxanone (PDO) is generally a safe treatment. PDO threads have been used in many research published in Asia[29]. Nevertheless, there is limited data on the incidence of PDO-related complications[41]. PDO threads are the oldest and are composed of a biodegradable synthetic monofilament polymer that has been utilized in surgery for a long time. PDO has colorless or dyed crystals and is sterilized by ethylene oxide. PDO threads are absorbed into the body over a period of six months by hydrolysis. They have a rubber-like texture at room temperature and a melting point of 110°C[42].

PDO threads are mostly utilized in three different forms: screw, cog, and mono filament (Figure 2).

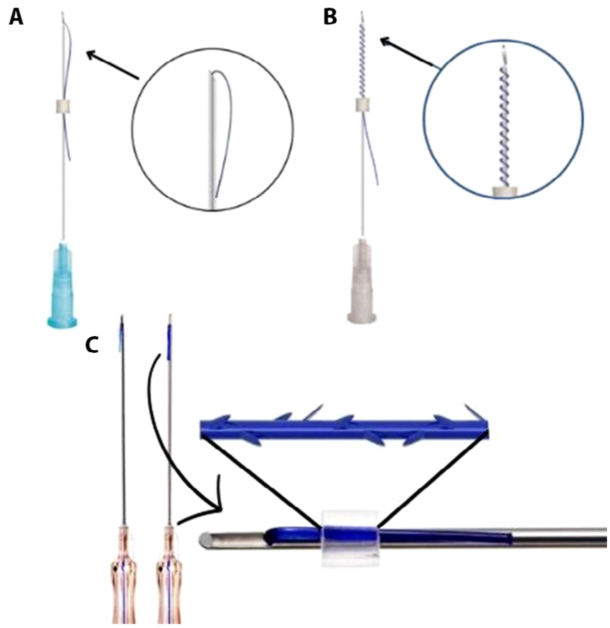

Figure 2. Type of PDO thread (A) smooth monofilament thread (B) spiral or screw monofilament thread (C) The barbed thread

Mono filament threads are fastened to a spot on the scalp or face, smooth, and barb-free. They give a little lift and mostly tighten the skin. Barbs on cog threads latch into the skin to raise and support drooping tissue. Screw threads offer effective volume restoration to depressed skin regions and feature one or two entwined threads surrounding the needle[11].

Thread-lifting is a technique used to treat ptosis that involves placing barbed sutures beneath drooping tissue in a precise direction[43]. After the threads are initially inserted into the dermis, the barbs anchor in the adipose tissue when tugged in the opposite direction, boosting the threads' tensile strength as they are hung in the dermis and surrounding tissue. The production of fibrous tissue induced by polydioxanone threads is followed by type 1 and type 3 collagen deposition and subcutaneous tissue suspension. This produces a novel tract of autologous tissue that facilitates the promotion of epithelial morphogenesis by inducing a mechanotransduction pathway through the transmission of stress. It was discovered that by converting fibroblasts into myofibroblasts, a new tissue tract that transmits the thread's force is established. Tension and therefore tissue position was demonstrated to be maintained by the contraction of these fibrous strains. Even six to twelve months after the thread has broken down, this stress causes the connective tissue to accumulate. Consequently, collagen deposition and long-lasting skin regeneration are caused by the presence of stimulated fibroblasts around the thread surface[9,36,44].

Myofibroblasts are involved in the contraction and healing of wounds, as well as the elasticity and tightness of the treated skin throughout the skin regeneration process[45]. Skin tone, texture, pore size, and elasticity will all be affected by the process of realigning loose tissue, myofibroblast and fibroblast production, and neo-collagenesis. Suspension methods are used to reorganize face tissues at the supraperiosteal level, elevating the superficial musculoaponeurotic system (SMAS). Moreover, the slack parts of the face will be lifted and tightened by the insertion of barbed sutures beneath the skin, improving contour and definition[9,29,46].

The elastic fibrosis and neo-collagenesis surrounding the thread, which transfers the tensile pressures and enables semipermanent tissue suspension, are the primary factors responsible for the long-lasting effects following thread lifts[44]. In a study looking at the histologic changes associated with the implantation of barbed PDO threads, samples taken one and three months after implantation showed the existence of visible threads encased in a fibrous sheath. The central aggregation of inflammatory cells and fibroblasts toward the suture material was seen in prominent tissue responses. The synthetic threads were hard to find seven months later. At the insertion locations, a granulation tissue made up of multinucleated giant cells and fibroblasts was seen[47].

Making a mesh and lifting procedures are two different kinds of operations that may be carried out using PDO threads. Using smooth threads, the mesh process resembles a net. Thin, smooth threads put subcutaneously in places with mild tissue resorption or hollowness will provide a mesh-like structure. The goal is to produce a mesh with smooth threads to promote healthy collagen and myofibroblast synthesis. This will increase the suppleness and texture of the skin, but it won't lift it. The cog thread lifting procedure is done by 4D and 6D bidirectional threads. To achieve a lift in the jowl area and the nasolabial fold, fixation points are often positioned on the most prominent malar bone or in front of the hairline above the zygomatic arch. The process will also aid in determining the quantity of sutures that will be applied[9]. The physician must be aware of muscle dynamics, soft-tissue anatomy, thread mechanics, and the immunologic processes related to suture placement in order to perform a facelift using barbed sutures that yield positive outcomes.

Facial regions like the perioral area might pose more challenges due to the abundance of muscular activity present. If these soft tissues were raised vertically, it would be difficult for the muscles to contract, resulting in the failure of the lift effect called cheese-wiring.

A study by Bertossi et al. (2019) reported that even after accounting for lift direction, they still observed significant cheese-wiring against the thread's rigid core and barbs, although the satisfaction rate on a visual analog scale (VAS) was very high (8-9 out of 10) at completion of the procedure for all patients[48]. According to Kirimi (2018), several hundred patients treated with barbed PDO threads reported satisfaction following the treatment; however, the longevity of lifting procedures depends on a number of factors, such as the patient's age and metabolism, the use of appropriate vectors and technique, and the quantity of threads inserted[49]. In line with the studies conducted by Khan G et al. and Cho et al. (2021), they demonstrated that the implantation of PDO thread is one of the most effective procedures for rejuvenating aged skin besides other materials such as PCL and PLLA[50,51]. Research by Ha Y et al. showed that, histologically, PDO threads increase the production of type 1 and 3 collagen and TNF-β, whereas PCL threads only enhance the production of type 3 collagen[52].

For these kinds of procedures, polydioxanone threads are commonly used as they are easily obtained from the market, completely biodegradable, and have little risk of complications. A study by Gerges et al. (2021) also emphasized that PDO threads are widely used because they employ a simple and quick technique with minimal side effects and do not require a long recovery period[10]. Unmanageable discomfort, thread extrusion, dimpling, sensory abnormalities, and foreign body responses are the most common complications.

The more threads used, the higher the chance of the complications. Early procedure problems include dimpling, thread exposure, alopecia, under-correction, asymmetry, and parotid gland damage[53]. Thankfully, most of these adverse effects are low to moderate in nature and are easily remedied by straightforward treatments that do not need permanent sequencing.

To minimize the complications, it is important to identify the surrounding structures, such as the parotid gland, various layers of the face, and the locations of nerves and vessels[53,54]. With the advancement of technology, PDO threads have become a preferred choice for combined treatments in both non-surgical and surgical procedures. For instance, combining PDO threads with fillers in non-surgical rhinoplasty has yielded more satisfactory results[55]. Similarly, some studies evaluating the effects of using PDO threads with dermal fillers demonstrated that this combination treatment is highly effective for correcting sagging and promoting tightening of the face, with very high patient satisfaction levels[49]. Additionally, there have been satisfactory results with PDO thread implantation after liposuction procedures in the United States, where it has been used to improve the position of the navel, permanently tighten the lower abdomen, and enhance the outcomes of liposuction[56].

The demand for nonsurgical solutions, particularly malar and mandibular lifts using absorbable PDO threads, is developing quickly in this era of "*lunchtime treatments*". These methods give instant and acceptable success rates up to one month after surgery. Although the procedure's effects began to diminish at the 6-month post-operative follow-up visit and disappeared after a year, the procedure has low complication rates, with an incidence of 11.2% of superficial thread displacement into the dermis and an infection rate of 6.2%. As such, it remains an option for minimally invasive face contouring treatments, or perhaps even a potential adjunct weapon in the surgeon's toolkit, much like fillers or botulinum toxin[32,48,57].

Conclusion

The increasing demand for anti-aging treatments, particularly regarding the skin, has driven continuous advancements in this field. One prevalent modality is the thread lift, which stimulates new collagen formation in the treated areas and provides a lifting effect, especially in regions experiencing sagging skin. PDO threads have been used for a long time and remain popular due to their accessibility and affordability.

Many studies have been conducted using PDO threads, and most of these show quite satisfactory results. Even though many new thread materials and collagen stimulation treatments have emerged, polydioxanone (PDO) threads still play a prominent role due to their low complication rates, ease of use, and extensive biomolecular research demonstrating their ability to stimulate fibroblast activity and collagen production.

Given these considerations, PDO threads continue to be a preferred choice for anti-aging treatments in the field of aesthetic medicine, supporting ongoing and new studies and technological advancements in their use.

Conflict of Interest: The authors declare that they have no conflict of interest.

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Authors' Declaration: The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

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Correspondence:
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Laksmi Trimurti Ni Nyoman Ayu MD
Magister Program in Anti-Aging Medicine, Faculty of Medicine, Universitas Udayana, Denpasar, Bali, Indonesia
E-mail: trimurtilaksmy@gmail.com