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CASE SERIES

A Case Series of Rare Long-Term Bruising Following Injection of Liquid-Form Polycaprolactone: Mechanisms and Therapeutic Insights

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Abstract: Post-procedural bruising is one of the most common complications of aesthetic injections. Liquid-form polycaprolactone (PCL) is generally considered safe, with only transient and self-limiting adverse events reported. While bruising after liquid-form PCL injections is typically short-lived and no cases of permanent bruising have been documented, some patients may experience bruising persisting for several months. To date, however, no published reports have described such long-term cases. Here, we present retrospective review on seven clinical cases of persistent bruising following liquid-form PCL injections to the infraorbital, puncture point, and upper arm regions, and summarize their clinical management. Therapeutic approaches included pigment fragmentation (PICO, Nd:YAG, IPL, PDL), thermal loosening of the scaffold–tissue complex (radiofrequency, high-intensity focused ultrasound, warm application), mechanical dispersion (microcurrent stimulation, ultrasound, normal saline washout, gentle massage), and enzymatic degradation (hyaluronidase, lipase). All patients ultimately achieved resolution, and no serious adverse events were observed. These findings suggest that long-term bruising, although rare, is clinically relevant and may be associated with dense liquid-form PCL scaffold entrapment of pigment molecules or a Tyndall effect. Importantly, this phenomenon is not permanent, as its resolution parallels scaffold degradation over time. Preventive strategies, combined with multimodal management tailored to the underlying mechanisms, may reduce patient discomfort and optimize aesthetic outcomes.

Keywords: polycaprolactone, dermal biostimulator, filler adverse effect management, bruising management

Introduction

In clinical practice, post-procedural bruising is one of the most common complications of aesthetic procedures, primarily resulting from trauma to the vessels that are often difficult to visualize under normal lighting conditions.[1–5] Bruising is characterized by the rupture of blood vessels within the dermis or subcutaneous tissue while maintaining continuity of the skin surface.[6–8] For clinical observation, the blood pressure must be high enough to cause red blood cell extravasation into the surrounding interstitial tissue, with leaked blood accumulating sufficiently near the skin surface to be visible.[9]

However, the extent and presentation of bruising are not uniform across individuals. Bruising is usually considered an early onset complication; however, persistent staining may occur in some patients.[10] Various factors influence the severity and spread of bruising, including the degree of tissue laxity and subcutaneous compliance.[4] This risk is particularly pronounced in anatomical regions characterized by fragile vasculature and loose connective tissue; this

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increases the likelihood of vessel injury during the injection of the neurotoxins or dermal fillers and also usually results in more extensive and conspicuous bruising compared to denser tissue areas, such as the periorbital region.[1,2,4,11]

Once a bruise is formed, its duration and resolution vary considerably between individuals.[4] Although various animal studies have attempted to standardize bruise assessments based on color changes and other parameters, no definitive criteria have been established.[4,12] Furthermore, the duration of bruising varies widely among individuals and may be influenced by multiple factors, including the use of corticosteroids, nonsteroidal anti-inflammatory drugs (NSAIDs), alcohol, antithrombotic herbal supplements, and other prescription medications; moreover, even with pharmacological interventions, such as corticosteroids, the time required for bruise resolution remains unpredictable, reflecting the complexity and variability of the healing process.[4,5,13]

A novel liquid-form polycaprolactone (PCL) has been introduced into the global aesthetic field as a promising option for soft tissue augmentation and regenerative treatments over the past several years.[14] In a randomized split-face study, Jeong et al[14] reported that liquid-form PCL was well tolerated, with no persistent skin abnormalities observed. The reported adverse events were limited to transient injection site edema, pain, pruritus, and erythema, and no serious or prolonged complications were identified.[14]

However, to date, no reports related to the use of liquid-form PCL have described prolonged bruising lasting more than 6 months. Despite preventive measures, persistent bruising may occur, significantly prolonging patients' discomfort following aesthetic procedures.[1,5] Here, we retrospectively present rare cases of persistent bruising that lasted for over several months following liquid-form PCL injection and outlined the therapeutic strategies applied for its resolution.

This report complied with the ethical standards of the Declaration of Helsinki, and all patients included in this case report provided written informed consent for publication, including the use of their clinical information and related images for academic purposes. Institutional approval was not required.

Case Presentation/Results

In the following seven cases, we present clinical outcomes observed after the management of long-term bruising following liquid-form PCL injection. The summary of each case, including bruising visibility scores (BVS) before the commencement of the treatment based on a 5-point scale[15] is provided in Table 1. The treatment modalities and parameter settings are summarized in Table 2.

Table 1 Clinical Cases Summary

Case No.	Age/ Sex	BVS	Bruising Localization	Injection Volume	Dilution	Treatment Used	Resolution Time (Baseline–First Treatment Day)
1	38/F	5	Infraorbital (left)	1 mL/side	None	532 nm PICO, 1 session	Within 1 month
2	38/F	4	Infraorbital (right)	1 mL/side	None	532 nm PICO, 2 sessions 1064 nm PICO, 1 session	3 months
3	56/F	5	Infraorbital (right)	1 mL/side	None	520 nm IPL, 2 sessions	5 days
4	36/M	4	Infraorbital (left)	1 mL/side	None	1064 nm Q-switched Nd:YAG & RF therapy, 3 sessions	2.5 months
5	59/F	3	Infraorbital (right)	0.5 mL/side	None	RF therapy, 7 sessions	3.5 months
6	36/F	4	Zygomatic area (right)	0.5 mL/side	None	HIFU, 2 sessions	2.5 months
7	33/F	3	Upper arm (right)	2 mL/arm	None	Hyaluronidase + gentle massage, 1 session	6 days

Abbreviations: BVS, 5-point scale Bruising Visibility Score; PICO, picosecond laser; IPL, intense pulsed light; RF, radiofrequency; HIFU, high-intensity focused ultrasound.

Table 2 Clinically Applied Strategies for Bruise Management

Category	Case No.	Parameter						
Laser		**Device**	**Wavelength (nm)**	**Pulse Duration**	**Energy (J/cm^2)**	**Spot Size (mm)**	**Frequency/ Pass**	**Session / Interval**
	1	PICO: StarWalker®	532 532	300 ps 300 ps	0.4 1.0	8 4	5 Hz / 1 5 Hz / 1	Single session
	2	PICO: StarWalker®	532 532 1064	300 ps 300 ps 300 ps	0.4 1.0 2.6	8 4 5	5 Hz / 1 5 Hz / 1 5 Hz / 1	3 sessions / 1-month interval
	3	IPL: Modula IPL®	520	17 ms	19–21	50 x 12	- / 1	2 sessions / 3-day interval
	4	Q-switch Nd: YAG: KingLaser®	1064	6 ns	0.26	8	10 Hz / 1	3 sessions / 1-month interval
RF		**Device**	**Tip type**	**Output mode**	**Output power (W)**	**Frequency**	**Duration (minutes)**	**Session / Interval**
	4	BTL-6000 TR-Therapy Elite	30 mm	Continuous	90	500 kHz	15	3 sessions / 1-month interval
	5	Polargen®	Unipolar	Continuous	400	40.68 MHz	5 (with manual palpation to monitor heat)	7 sessions / 2-week interval
HIFU		**Device**	**Cartridge type**	**Depth (mm)**	**Energy (J/cm^2)**	**Frequency (MHz)**	**line**	**Session / Interval**
	6	UltraformerIII ®	L7-3.0	3.0	0.5	7	12	2 sessions / 2-week interval
			MF2	2.0	0.3	5.5	8	
Enzyme	**7**	**Enzyme**	**Product**	**Form**	**Injection volume**	**Composition**		
		Hyaluronidase	Hirax®	Liquid	0.6cc	Hyaluronidase 1500IU/mL, Sodium Chloride, Lactose Monohydrate, WFI		

Abbreviations: PICO, picosecond laser; Nd:YAG, neodymium-doped yttrium aluminum garnet laser; IPL, intense pulsed light; RF, radiofrequency; HIFU, high-intensity focused ultrasound.

Case 1

A 38-year-old Japanese female, with no known drug allergies and no history of current medications or underlying medical conditions, presented for aesthetic treatment to improve infraorbital hollowing and achieve a lifting effect. On August 5, 2023, she underwent an injection of 2 cc of liquid-form polycaprolactone (GOURI®, Dexlevo, South Korea) with 1 cc administered into each infraorbital area, administered using a 25G 50 mm cannula. However, as the bruising in the left infraorbital region persisted without improvement after one week, she returned to the clinic for further management. Adjunctive treatment was performed using a 532 nm picosecond laser (StarWalker®, Fotona, Slovenia) with two settings: 0.4 J with an 8 mm spot size and 1.0 J with a 4 mm spot size, each delivered in a single pass (two passes in total) (Figure 1). After this single session, bruising showed marked improvement.

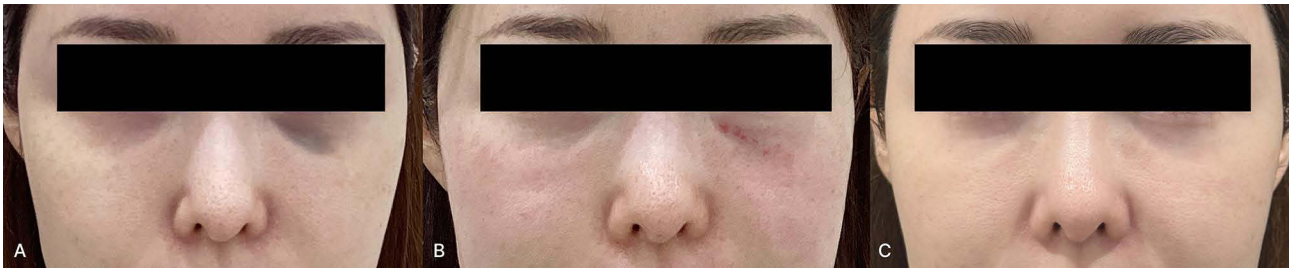

Figure 1 Clinical course of a patient with left infraorbital long-term bruising treated with PICO laser. (**A**) August 13, 2023, immediately before treatment; (**B**) August 13, 2023, immediately after treatment (same day); (**C**) September 3, 2023, three weeks post-treatment.

Case 2

A 38-year-old Japanese female, with no known drug allergies, current medications, or underlying medical conditions, consulted at our clinic. The patient had no significant medical history and reported no ongoing treatment. On December 13, 2023, she underwent injection of 2 cc of liquid-form PCL (GOURI®) with 1 cc administered into each infraorbital area using a 25 G 50 mm cannula to address infraorbital hollowing, after which persistent bruising at right under eye developed.

For treatment, she received three sessions of PICO second laser (StarWalker®) at one-month intervals: the first session on April 22, 2024, the second session on May 21, 2024, and the third session on July 2, 2024, using the following parameters: 532 nm, 0.4 J/cm^2, 8 mm spot, 532 nm, 1.0 J/cm^2, 4 mm spot, and 1064 nm, 2.6 J/cm^2, 5 mm spot size, each delivered in one pass (three passes in total). At her follow-up on July 30, 2024, 1 month after the third session, the bruising showed marked improvement (Figure 2). After approximately three sessions, there was a marked reduction in bruising with progressive fading and eventual restoration of normal skin tone.

Case 3

A 56-year-old female patient developed infraorbital bruising following liquid-form PCL (GOURI®) injection. On July 29, 2025, a total of 2 cc of undiluted liquid-form PCL was administered, with 1 cc injected into each side of the middle part of the face along the infraorbital vector region, using a 23 G 50 mm cannula. Bruising was first noted on July 30, the next day after the treatment, localized to the infraorbital area on the right side. The patient had no significant medical history, was not taking anticoagulants or antiplatelet medications, and reported no drug allergies.

As an early management strategy, intense pulsed light (IPL; Modula IPL®, Wavemed, Italy) was applied on July 31, 2025. To balance the efficacy and safety, the treatment parameters were adjusted to slightly lower fluence levels than those typically used for facial telangiectasia. For Fitzpatrick skin types I and II, where fine vessels are usually treated at 22–23 J/cm^2, the fluence was reduced to 19–21 J/cm^2 with a 520 nm filter, 17 ms pulse duration, and 50×12 mm spot size. The treatment was delivered in a single pass and repeated across two sessions at a 3-day interval. By August 1, 2025, progressive fading of the bruise was documented, and on August 3, 2025, complete resolution was observed without residual bruising, recurrence, or adverse events, such as edema, erythema, or post-inflammatory hyperpigmentation (Figure 3).

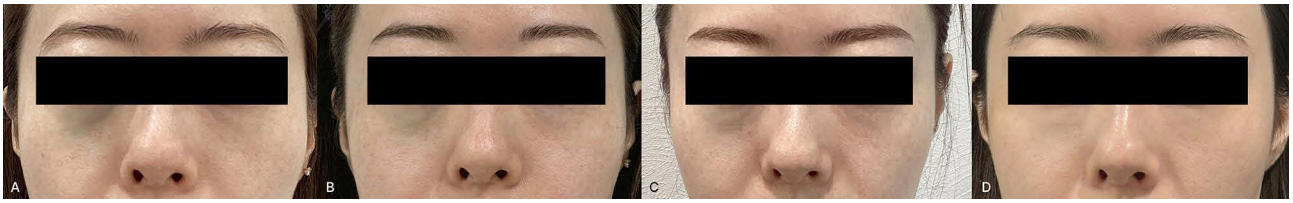

Figure 2 Clinical course of a patient with right infraorbital long-term bruising managed with serial PICO laser. (**A**) April 22, 2024, before the first session; (**B**) May 21, 2024, one month after the first session; (**C**) July 30, 2024, one month after the second session; (**D**) August 27, 2024, one month after the third session.

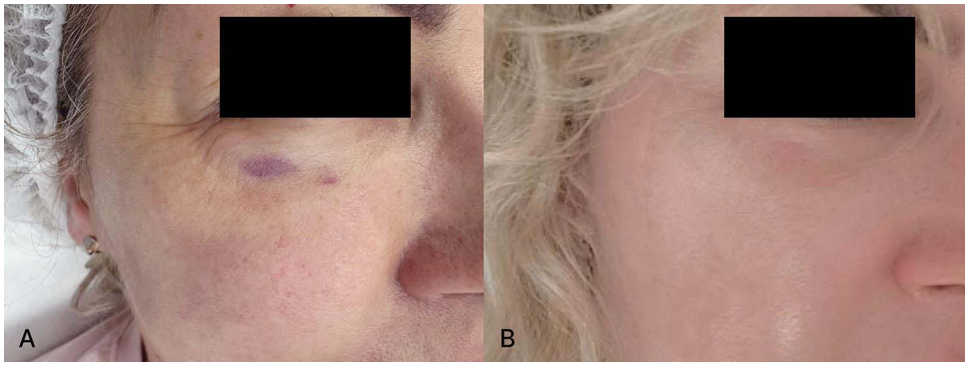

Figure 3 Clinical application of intense pulsed light (IPL) for right infraorbital long-term bruising after liquid-form PCL injection. (**A**) July 31, 2025, immediately before the first IPL treatment; (**B**) August 3, 2025, one day after the second IPL session, showing resolution of bruising.

Case 4

On March 28, 2025, a 36-year-old male patient underwent injection of a total of 3 cc of undiluted liquid-form PCL (GOURI®), with 1 cc administered into the forehead, 1 cc into the midface, and 1 cc into the lower face, using a 23 G 50 mm cannula. Despite 3 months of observation, persistent bruising in the left infraorbital area showed no improvement.

On June 22, 2025, combination therapy with a Q-switched Nd:YAG laser (KingLaser® KL-M(H), Jilin Province King Laser Co., Ltd., China) followed by a radiofrequency device (BTL-6000 TR-Therapy Elite, BTL Industries, Czech Republic) was initiated. The Q-switched Nd:YAG laser was applied with the following parameters: wavelength 1064 nm, pulse duration 6 ns, energy density 260 mJ/cm^2, spot size 8 mm, frequency 10 Hz, and one pass. The subsequent RF treatment was delivered at a depth of 4–6 mm, maintaining tissue temperature between 40–50 °C for 15 minutes. The patient underwent three treatment sessions on June 22, July 23, and August 25, 2025. On September 3, 2025, ten days after the third session, a marked improvement in the bruising was observed (Figure 4).

Case 5

A 59-year-old female patient with prominent infraorbital wrinkles visited our clinic for aesthetic improvement. On December 16, 2024, she received bilateral injections of liquid-form PCL (0.5 cc per side, total of 1 cc, undiluted GOURI®), administered using a 25 G 50 mm cannula. On the same day, she also underwent filler (Restylane® LYFT™ Lidocaine, Galderma, Sweden) injection (0.5 cc per side, total of 1 cc) in both infraorbital regions after liquid-form PCL injection. On December 27, 2024, the patient reported persistent bruising in the right treated area that had not subsided.

After a period of clinical observation, radiofrequency (RF) therapy (Polargen®, Unionmedical, South Korea) was initiated as the first management approach on February 4, 2025. The RF procedure was performed using an energy setting of 80 W for approximately 5 min with continuous manual palpation to monitor tissue temperature and prevent burns. The RF treatment was repeated every 2 weeks, and gentle manual massage was performed during each session. The patient

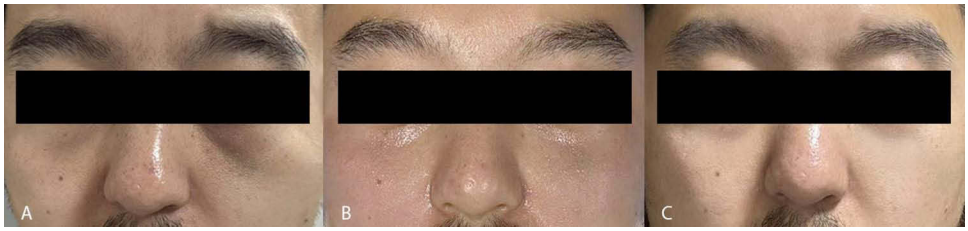

Figure 4 Clinical course of a patient with left infraorbital long-term bruising after liquid-form PCL injection treated with combined Q-switched Nd:YAG laser and RF therapy. (**A**) June 22, 2025, immediately before the first treatment session; (**B**) July 23, 2025, one month after the first session, immediately before the second treatment session; (**C**) September 3, 2025, ten days after the third session, showing marked improvement.

received seven RF sessions over approximately 3.5 months, which resulted in a significant improvement in long-term bruising after the procedure (Figure 5). No adverse events, such as burns, were reported during the course of treatment.

Case 6

A 36-year-old female patient presented with persistent bruising at the zygomatic cannula entry point following liquid-form PCL (GOURI®) injection. On August 15, 2023, she received a liquid-form PCL injection, followed by Teosyal Redensity® 2 (TEOXANE, Switzerland) (1cc) on August 28, 2023. A second undiluted injection of liquid-form PCL (volume: 1 cc, delivered via a 23 G 50 mm cannula) was administered to the middle part of the face region on October 6, 2023. After the second procedure, the patient developed long-term bruising localized at the liquid-form PCL entry point on the right side of the face.

As a therapeutic approach, high-intensity focused ultrasound (HIFU; Ultraformer III®, Classys, South Korea) was initiated. The first HIFU session was performed on December 6, 2023, using both a linear transducer (L7, 3.0 mm depth, 0.5 J, 12 shots) and a microfocused transducer (MF-2, 2.0 mm depth, 0.3 J, 8 shots). Two treatments were administered per session. A follow-up photograph taken on February 22, 2024, revealed near-complete resolution of persistent bruising, with no adverse events, such as significant pain, edema, or thermal injury (Figure 6).

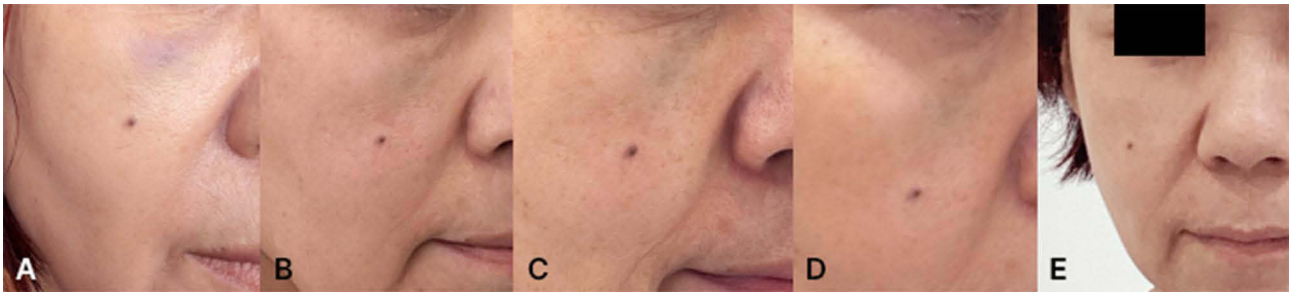

Figure 5 Clinical course of a patient with right infraorbital long-term bruising managed with RF therapy. (**A**) December 27, 2024, 11 days post-injection, initial report of persistent bruising; (**B**) February 4, 2025, first RF treatment (7 weeks post-injection); (**C**) March 13, 2025, third RF session (12 weeks post-injection); (**D**) April 17, 2025, fifth RF session (17 weeks post-injection); (**E**) June 12, 2025, after seven biweekly RF sessions.

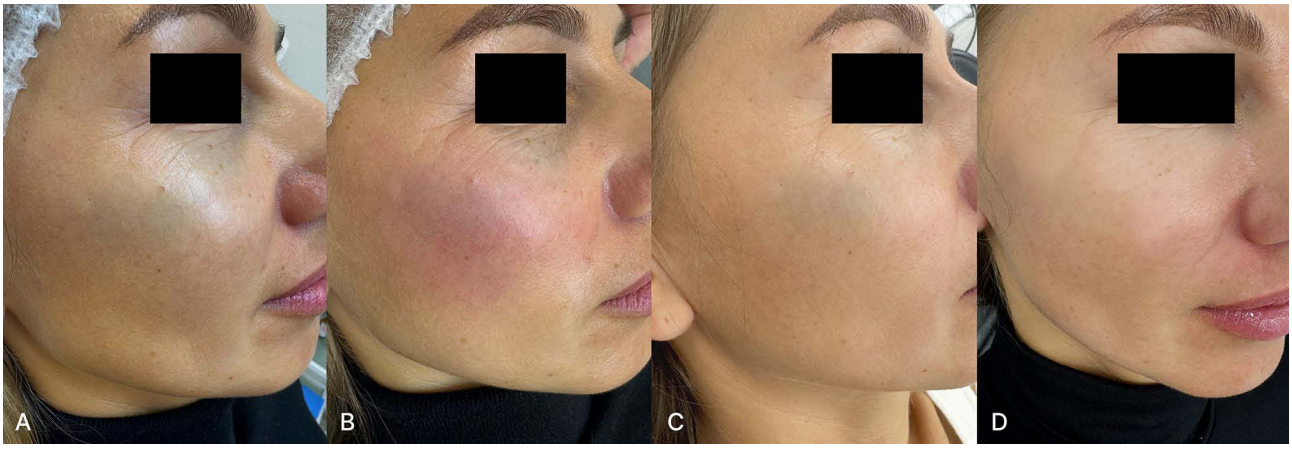

Figure 6 Clinical course of a patient with right entry-point long-term bruising treated with HIFU. (**A**) December 6, 2023, immediately before the first HIFU session; (**B**) December 6, 2023, immediately after the first session (same day); (**C**) December 14, 2023, eight days after the first session, immediately before the second session; (**D**) February 22, 2024, two and a half months after treatment, showing resolution of bruising.

Case 7

On May 1, 2025, a 33-year-old patient received an injection of liquid-form PCL (GOURI®) for skin tightening. A total of 4 mL was administered, and 2 mL was injected into each upper arm region. Subsequently, the patient developed a long-term bruising on her right arm measuring approximately 3 cm in diameter, which did not resolve after 1 month.

To address this, a treatment was performed using liquid-type hyaluronidase (Hirax® 1,500 IU/mL, BMI Korea, South Korea). A total of 0.6 cc was injected directly into the bruised area using a 30 G needle, followed by gentle massage of the region for 3 min for drainage. Immediately after hyaluronidase administration, the patient reported mild pain and redness in the injected area, which were attributed to the hyaluronidase injection. However, the throbbing discomfort experienced at the site resolved the following day. Three days after treatment, the bruising site demonstrated a yellowish discoloration, indicating resolution of the hemoglobin degradation products. By day 6 post injection, the bruising had completely subsided (Figure 7).

Discussion

Liquid-form PCL represents a new formula of polycaprolactone-based biostimulator, which is composed of PCL polymer chains in a size of less than tenth of micrometers, as compared to currently available conventional fillers, which have an average particle size of 25–50 μm.[16] 1 mL syringe of liquid-form PCL is composed of 21% of polycaprolactone homogenously dispersed in distilled water. After injection, it forms a homogeneous scaffold within the dermal tissue, delivering fundamental skin-tightening, lifting, and natural volumizing effects. Owing to these unique properties, it has emerged as a noteworthy innovation in the next-generation collagen stimulator market. Currently approved in more than 40 countries worldwide, this global product overcomes several limitations of conventional biostimulator fillers. Unlike conventional polymer products composed of particles ranging from tens to hundreds of micrometers in size, liquid-form PCL minimize risk of microparticle-induced vascular complications, such as occlusion of ophthalmic artery branches of which no cases have been reported globally. This structural distinction not only enhances its safety profile but also highlights its clinical potential as a novel and versatile collagen biostimulator.

Mechanism of Long-Term Bruising of the Liquid-Form PCL

Bruising is primarily caused by damage to the vessels within the subcutaneous tissue layer, resulting in the extravasation of blood into the surrounding interstitial space.[3] Once extravasated, the blood follows the natural anatomical planes between the dermis and subcutaneous fat, where it disperses and accumulates.[3] This subdermal pooling of blood components manifests externally as visible skin discoloration, commonly recognized as bruising.[3] The discoloration of a bruise arises from erythrocyte lysis outside the vasculature, leading to hemoglobin release and its oxidation to methemoglobin, which is subsequently metabolized into pigments such as biliverdin and bilirubin.[17]

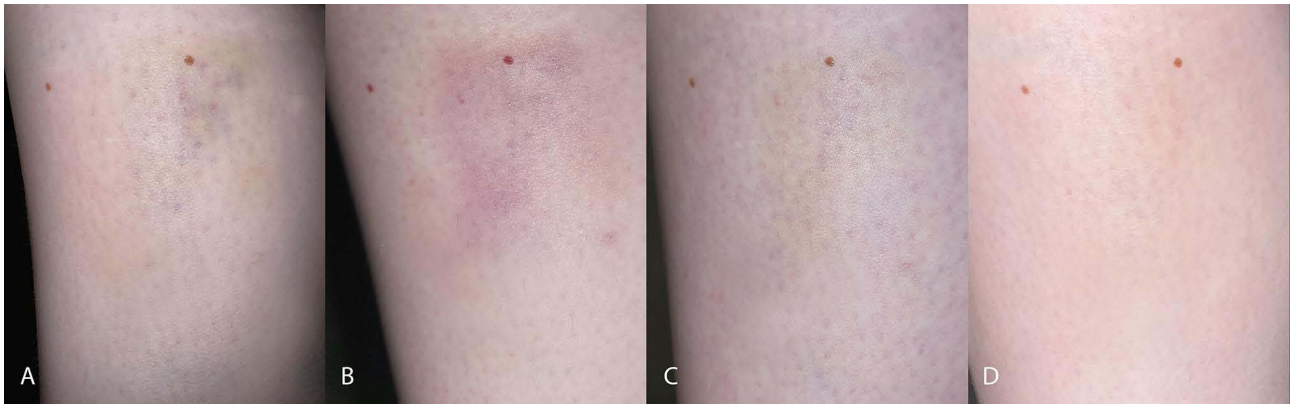

Figure 7 Clinical course of a patient with long-term bruising after liquid-form PCL injection into the right upper arm, treated with liquid-type hyaluronidase (0.6 cc). (**A**) June 1, 2025, immediately before treatment; (**B**) June 1, 2025, immediately after injection (same day); (**C**) June 4, 2025, three days post-treatment; (**D**) June 7, 2025, six days post-treatment.

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Long-term bruising after liquid-form PCL injection has been reported mostly in the infraorbital region. In representative cases, the bruising sites were observed in anatomical locations corresponding to the course of the angular artery and vein. It is presumed that the bleeding originated from vascular injury in this area and extended along the tear trough, resulting in pronounced and long-term bruising under the eye. Given that the angular vessels are relatively large and the overlying skin is thin, vessel injuries can lead to considerable bleeding and visible bruising. Similarly, prolonged bruising has also been documented in the malar and zygomatic region, where large vessels such as transverse facial artery and zygomaticofacial artery are located, as well as around the perioral area along the course of the facial artery and vein (Figure 8).

In addition, across all clinical and experimental observations, long-term bruising following injection resolved in parallel with the degradation of the liquid-form PCL scaffold, confirming that the bruising condition is not permanent. It is hypothesized that the pigment molecules generated during hemoglobin degradation, such as biliverdin and related heme catabolites, may be temporarily sequestered in the liquid-form PCL scaffold. As the scaffold undergoes gradual hydrolytic breakdown, these pigments are progressively released and subsequently cleared via physiological pathways.

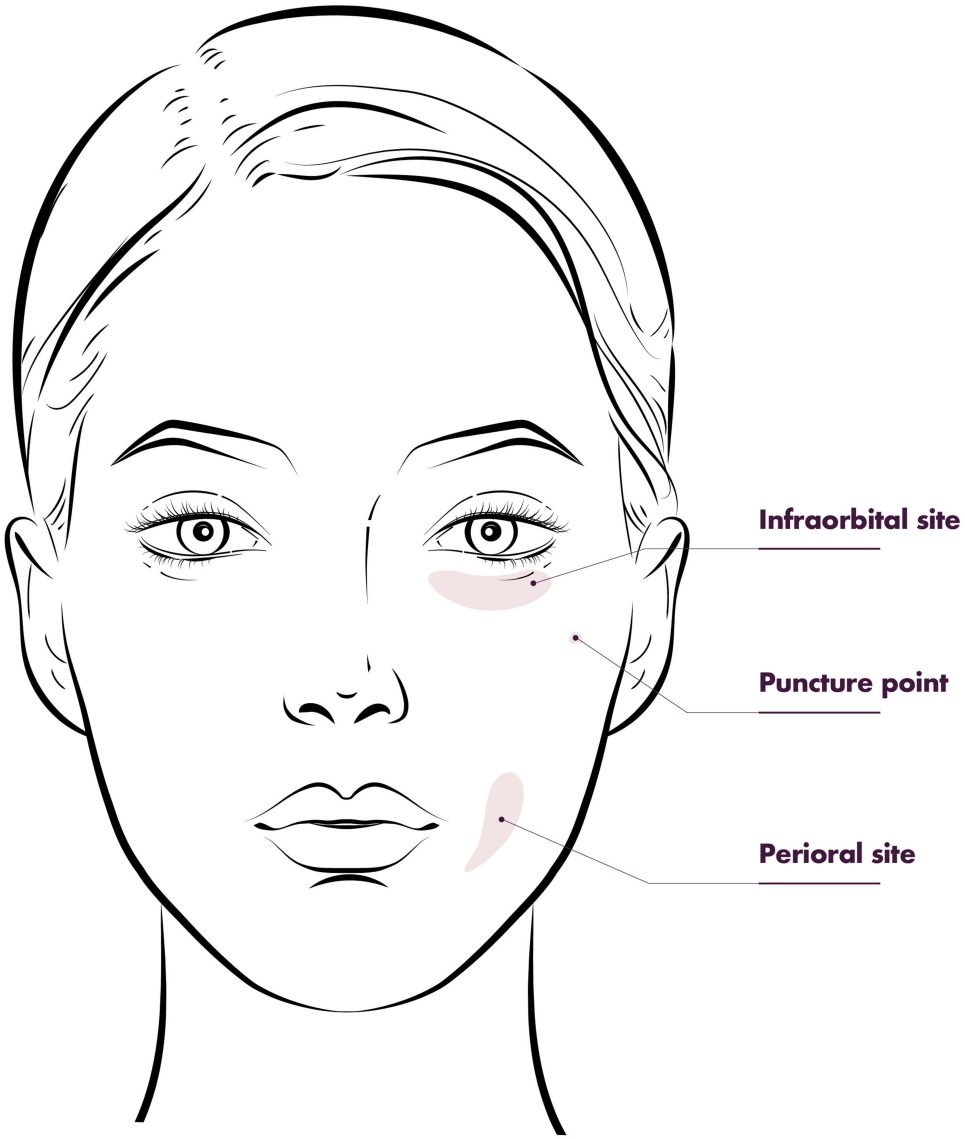

Figure 8 Representative anatomical sites of long-term bruising after liquid-form PCL injection.

Several mechanisms may contribute to the persistence of post-procedural bruising following the injection of liquid-form PCL.

Scaffold Entrapment of the Pigment Molecules

Following dermal injection, the liquid-form PCL forms an interconnected scaffold structure. If vascular injury occurs during the procedure, blood components may extravasate into the surrounding tissue.[18] Then hemoglobin and its metabolites may become sequestered within the dense scaffold, hindering enzymatic and phagocytic clearance. Especially, free heme released from methemoglobin (as porphyrin-Fe (III)) is extremely lipophilic and intercalates into lipid structures,[19] potentially including the hydrophobic domains of liquid-form PCL. Also, biliverdin, the green pigment, and subsequently bilirubin is produced from methemoglobin through the action of heme oxygenase in an energy-dependent, oxygen-requiring process that releases carbon monoxide and iron atoms.[9,20] This mechanism could explain the unusual long-term bruising observed in some cases. In contrast, from clinical perspective, when the liquid-form PCL formulation was diluted to create a less compact scaffold (Figure 9) or administered transepithelially using a spray-like needleless injection technique and/or multi-needle devices providing a more dispersed distribution (Figure 10), it was observed that the likelihood of prolonged bruising was significantly reduced. To our knowledge, long-term bruising using these alternative approaches has rarely been reported in clinical practice. Although not yet fully elucidated, this hypothesis is consistent with the clinical course observed in certain cases of long-term bruising following the use of dense liquid-form PCL scaffolds.

Tyndall Effect

The injection of liquid-form PCL into the superficial dermis layer can result in light scattering due to the presence of polymer particles, leading to the Tyndall effect and blue-gray discoloration of the skin.[10] Since discoloration becomes visible only when the extravasated blood is located close to the skin surface,[9] the depth of injection can be considered a critical factor. A comparable phenomenon is observed with hyaluronic acid (HA) fillers, where light refraction causes deeper dermal melanin to appear bluish, producing an effect known as "Mongolian spot".[21] The Tyndall effect often resembles a mild, deep bruise and is frequently mistaken for one; however, unlike general bruising, it remains unchanged over time unless the material is degraded or physically removed.[1,21] Long-term discoloration associated with liquid-form PCL may represent long-term bruising, which tends to resolve in parallel with polymer degradation. The Tyndall effect may likewise diminish as the material degrades and, in thin-skinned regions such as the infraorbital area, may account for

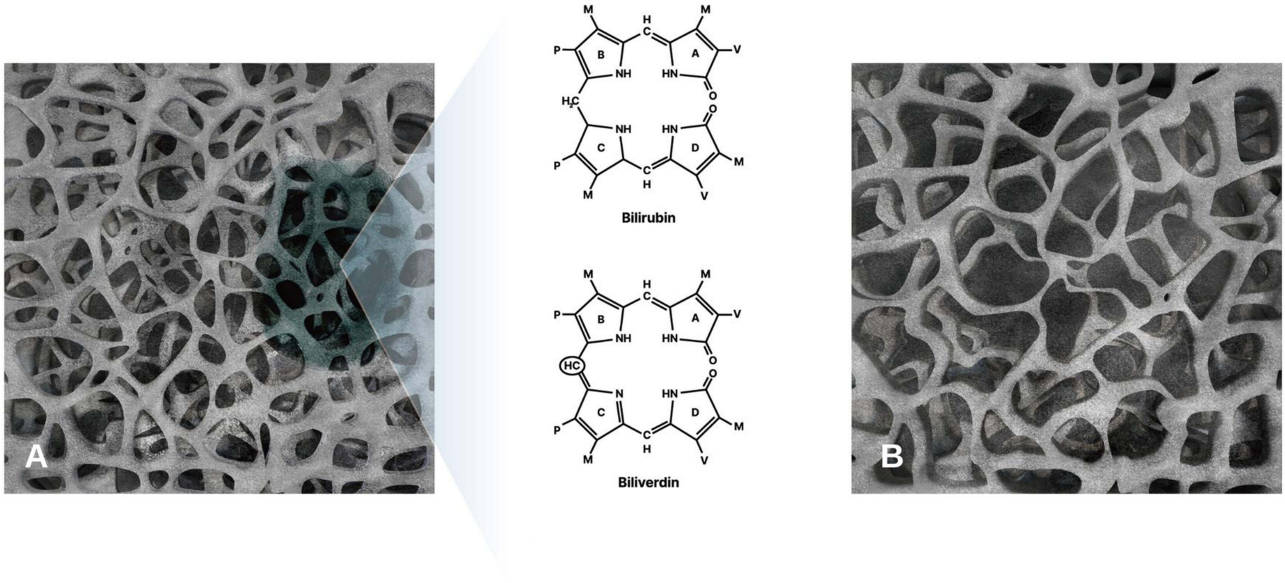

Figure 9 Representation of pigment molecules retained within (**A**) dense (undiluted) versus (**B**) loose (diluted) liquid-form PCL scaffolds.

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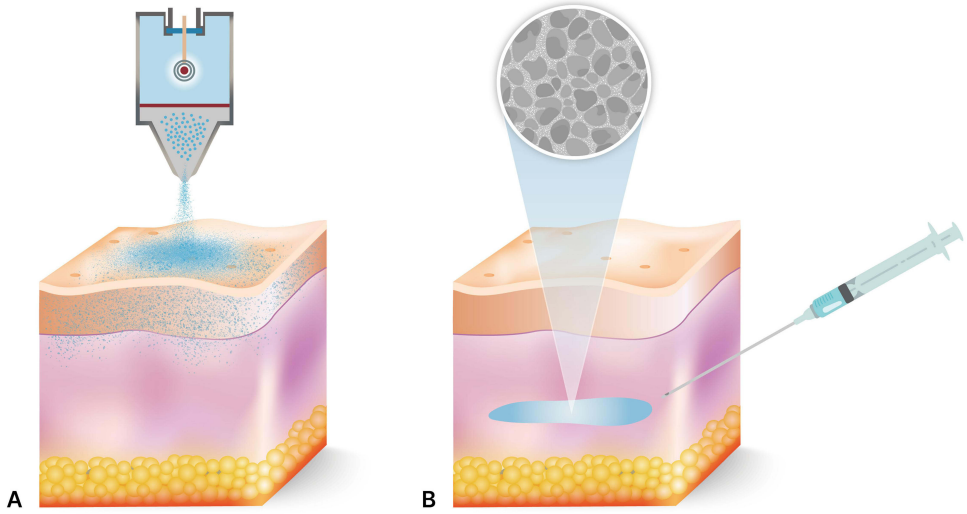

Figure 10 (**A**) Trans-epithelial injection with a needless injector injection with a needleless device; (**B**) Dense scaffold formation of liquid-form polycaprolactone in dermis to subcutaneous tissue after cannula injection.

part of the visible discoloration. In addition, the Tyndall effect may also contribute to the apparent persistence or accentuation of bruising in these areas.

Patient and Procedure-Related Factors

Inter-individual variability in vascular integrity, lymphatic drainage, and tissue regeneration capacity may also influence the duration of bruising.[9] Fragile blood vessels, slow clearance mechanisms, and heightened inflammatory responses can predispose individuals to long-term bruising. In addition, multiple factors, including cannula/needle size, injection depth, patient-specific conditions (such as age, general health status, vascular fragility, and liver dysfunction), and concomitant medications (eg, aspirin, warfarin, NSAIDs, vitamin E, and fish oil) have been reported to affect the risk of bruising and hematoma formation.[22,23] Importantly, these risk factors should be carefully assessed before the procedure to minimize long-term bruising.[24] Injection techniques such as fanlike cannula movement, rapid injection with high flow rates, or the use of larger volumes, are associated with an increased risk of local adverse events including bruising.[25] The fanning method in particular has been reported to cause more bruising than other techniques.[25]

Preventive Approaches to Procedure-Related Bruising

Bruising is a common and often acute side effect of aesthetic procedures when the vessels are inadvertently injured during injection. Even in cases of minor bleeding, prompt and adequate compression of the bleeding site is strongly recommended to prevent the further formation of significant bruises or hematomas.[23]

These preventive and management strategies for procedure-related bruising are summarized in Table 3.[5,23–31] Preventive strategies include the application of cold compresses both before and after the procedure and the use of vasoconstrictive agents, such as epinephrine in combination with lidocaine during local anesthesia, to minimize bleeding.[23,24] Also, creating a tunneling pathway with tumescent solution prior to liquid PCL injection loosens the tissue and induces vasoconstriction, which may help reduce the risk of bruising. Additionally, patients taking anticoagulants or antiplatelet medications should be advised to discontinue these agents several days before the invasive procedure, when clinically appropriate, to reduce the risk of bruising.[22,24] Also, the puncture point should not be made excessively deep, and if bleeding occurs, an alternative entry site slightly proximal to the original puncture should be selected. Immediate and firm compression should be applied to ensure adequate hemostasis before proceeding with further injections.

Maintaining a gentle, deliberate, and slow injection technique remains one of the most critical factors for minimizing vascular complications.[22,32] The risk of bruising is reduced with slow injections.[10] Using a blunt, cannula of A cannula of

Table 3 Strategies for Preventing and Minimizing Procedure-Related Bruising

Procedure Phase	Recommended Approach
Before Procedure[5,20–23]	1. Assess the patient's bleeding tendency in advance, including a history of anticoagulant or antiplatelet use. 2. Inform patients that bruising caused by this product may persist longer than expected, and provide this precaution prior to the procedure. 3. Apply cold compress to the treatment area prior to injection. 4. Use lidocaine with epinephrine to minimize bleeding risk. 5. Consider tumescent solution to reduce trauma. Example composition: Normal saline 500 mL, 2% Lidocaine 20 mL (1 vial), Epinephrine (1 mg/mL) 2 mL (2 ampoules), Sodium bicarbonate 1.68 g/20 mL (1 ampoule), Triamcinolone 40 mg/mL 0.5 mL (0.5 vial) 6. Apply firm compression to the bleeding site as needed. Re-entry may be attempted after complete hemostasis.
During Procedure[5,20,22,24–26]	1. The puncture point does not need to be made excessively deep. 2. Ensure complete hemostasis of the puncture point before proceeding with the procedure. 3. If bleeding occurs, create a new puncture point at a more proximal site along the intended cannula direction. 4. Avoid injections immediately adjacent to the puncture point, as the low-viscosity liquid formulation may leak out through the entry site due to pressure gradients; maintain at least a 1 cm distance from the puncture point. 5. Inject gently and slowly in retrograde technique. 6. Use blunt-tipped large gauge cannulas. 7. Avoid injecting into areas with active bleeding. 8. Special care should be taken in regions with prominent blood vessels (eg, periorbital entry points, perioral area). 9. No need for very superficial injections. The clinical outcome does not significantly differ. 10. Inject into the deep dermis - subcutaneous layer where resistance is minimal. 11. Pre-injecting lidocaine with epinephrine along the cannula path can help reduce the risk of bleeding.
After Procedure[5,20,23,27,28]	1. Ice packs: Apply for ≤15 minutes per session, at least 3 times daily for the first 1–2 days. 2. Avoid heat (eg, saunas, hot showers, sun exposure) for 48 h. 3. Avoid strenuous exercise for 48 h. These measures are required if bruising develops after the procedure. 1. Tranexamic acid (TXA) injection: Consider intralesional TXA injection for patients with significant or persistent bruising. 2. Topical bruise creams: Apply topical agents such as 20% Arnica, vitamin K cream, or heparin-based formulations to accelerate resolution. 3. Advise the patient to visit a clinic if bruising persists for more than 2 weeks.

moderate gauge, neither excessively thick nor thin, which is less likely to pierce a vessel and avoids excessive tissue manipulation or aggressive tunneling, can help minimize the risk of hematoma formation.[23] When localized swelling suggests potential vessel trauma, immediate cannula withdrawal and firm compression are recommended to control bleeding, prevent further tissue injury, and establish a new entry point.[23]

Furthermore, injections in anatomically sensitive areas, such as the infraorbital region, require caution. Overcorrection of the tear trough can result in unexpected outcomes, including bruising and Tyndall effect.[23] Given the proximity of significant vascular structures, precise technique and depth control are essential to avoid vascular compromise and ensure optimal results.[23] Notably, because the material is in liquid-form, it spreads not only horizontally but also vertically, producing a natural volumizing effect even when injected deeply in the infraorbital region. For patients concerned about bruising, placement in deeper layers such as the subcutaneous plane remains a safe and effective option. Furthermore, due to its liquid nature, fanning techniques are unnecessary; instead, a few smooth linear injections at the target site are sufficient for correction.

Clinical Approaches to Managing Long-Term Bruising

A review of 41 studies out of 13,110 database search results indicated that available methods for bruise discoloration are limited and lack substantial clinical evidence.[17] Thus, it can be concluded that no established treatment methods exist at

present, although some approaches provide preliminary insights into the potential use of hematoma dissolution agents like alkaline solution of hydrogen peroxide.[17] Nevertheless, the need for effective therapeutic strategies remains.[17] In addition to nonclinical preventive strategies, patients with long-term bruising after liquid-form PCL injections should be considered for clinical interventions.

Various therapeutic modalities have been explored in this study for the management of long-term bruising. Reported approaches include LDM® (Wellcomet, Germany) ultrasound for the mechanical dispersion of tissue and trapped blood components, PICO laser for pigment fragmentation, radiofrequency (RF) to soften the scaffold–tissue complex, long-pulsed Nd:YAG for targeting residual pigment molecules, IPL for vascular and pigment clearance, and an enzymatic strategy. As summarized in Table 4, the therapeutic approaches can be broadly categorized into four mechanistic strategies: pigment fragmentation, thermal loosening of the scaffold structure, mechanical dispersion, and chemical degradation.

Pigment-targeting techniques, such as IPL, PICO, Nd:YAG, and pulsed dye lasers, are designed to fragment chromophores and accelerate pigment clearance. Thermal approaches, including RF, HIFU, or warm applications, seek to soften the scaffold–tissue complex and enhance local circulation. Mechanical dispersion methods, such as saline washout or gentle massage, aim to redistribute trapped blood components physically. Finally, enzymatic degradation strategies involve agents, such as hyaluronidase or enzyme formulations. Notably, products that combine lyase, collagenase, and lipase in a single preparation appear to be more effective in promoting multifaceted biochemical breakdown.

Vascular lasers, such as the pulsed dye laser or potassium titanyl phosphate (KTP) laser, are most recommended for persistent hemosiderin staining since they have been reported to help speed up recovery.[33] In addition, various laser modalities including the pulsed dye laser, Nd:YAG laser, Q-switched laser, green-light potassium titanyl phosphate laser, and red-light therapy, are frequently employed to reduce bruising after cosmetic injections; however, the precise mechanisms for bruise resolution remain debated.[5,29,34,35] The 1064 nm wavelength penetrates deeply into the dermis while minimizing melanin absorption and selectively targeting hemoglobin degradation products, making it suitable for use across a wide range of skin types.[36] In addition, the ultrashort pulse duration of a picosecond laser (10^{-12} s) generates higher peak power than nanosecond devices, thereby reducing photothermal effects while enhancing photomechanical effects that can mechanically disperse hemosiderin with minimal risk of heat-induced tissue injury.[36–38] The picosecond 532 nm laser has also been regarded as an effective modality for eliminating both epidermal and dermal pigments.[39,40] However, in the context of bruise management, the 1064 nm wavelength is generally considered the safer first-line option. In this case report, the clinical observations suggested that various laser therapies, such as PICO, IPL, and Nd:YAG, may accelerate the breakdown of pigment deposits and improve long-term post-injection bruising.

Also, PCL is a hydrophobic polymer with a melting point in the range of 59–64 °C, allowing it to be easily processed at relatively low temperatures.[41] This characteristic provides the basis for the thermal loosening of the scaffold structure, which has been identified as one of the four therapeutic mechanisms for managing long-term bruising associated with liquid-form PCL. Mechanical dispersion strategies, such as Ultrasound (LDM® bruising mode), Microcurrent stimulation

Table 4 Long-Term Bruising Treatment Options

Pigment Fragmentation (Laser)	Thermal Loosening of the Scaffold Structure	Mechanical Dispersion	Chemical Degradation (Enzymes)
PICO	Radiofrequency (RF, Thermolysis)	Ultrasound (LDM® bruising mode)	Hyaluronidase
Q-switched Nd:YAG	HIFU (High-Intensity Focused Ultrasound)	Microcurrent stimulation (U-Cell®)	Lipase (+ Llyase + Collagenase)
Long-pulsed Nd:YAG	Warm pack	Normal saline washout (5–10 mL)	
IPL (Intense Pulsed Light) PDL (Pulsed Dye Laser)		Gentle massage	

(U-Cell®, Saeik medical CO., LTD, South Korea), normal saline flushing and gentle massage, help resolve bruising by physically disrupting the captured blood pigment within the dense liquid from the PCL scaffold, thereby enhancing pigment spread and facilitating clearance from the tissue.

Finally, PCL biodegradation has been reported to occur through the action of microorganisms or enzymatic processes.[42] In line with these enzymatic effects, hyaluronidase effectively resolved bruising within a short period in this case report (Case 7). In addition to cosmetic applications, hyaluronidase facilitates the absorption and dispersion of other injected drugs.[43] In addition to hyaluronidases, lipases also degrade PCL. Thangunpai et al reported that the weight of neat PCL remained unchanged for 120 h in the absence of lipase, whereas in the presence of lipase, the weight rapidly decreased, and the polymer was completely degraded within the same period.[44] Other studies have further analyzed the degradation rate and efficiency of various types of lipases and consistently observed that enzymatic degradation proceeds faster than hydrolytic degradation; while the former follows a superficial erosion mechanism, the latter is characterized by bulk erosion.[45–48]

In conclusion, strategies that promote a looser scaffold network and enhance drainage of blood pigments may be clinically useful in mitigating long-term bruising. However, previous attempts to manage prolonged bruising have usually been confined to single modalities, which may provide partial benefits but remain limited when acting alone. As each approach targets only one aspect of the underlying pathophysiology, a single mechanism is unlikely to achieve optimal clearance. In contrast, combining the four mechanistic strategies in a complementary manner is expected to yield a faster and more effective resolution for bruising.

Limitations

Despite the inclusion of multiple clinical cases, the sample size was limited, reducing the generalizability of the findings. Further studies with larger cohorts, repeated experimental validation, controlled comparison and detailed histological analyses are warranted to support and expand the observations reported herein. In particular, validation of the hypotheses proposed in the discussion through animal studies and controlled experimental models in future research is necessary.

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