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Different Types of Auricular Keloids and Treatment by Intralesional Cryosurgery: Best Practice for Obtaining Long-Lasting Clinical Results

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Keywords
Intralesional cryosurgery · Auricular keloids · Best practice · Ear

Abstract
Background: Auricular keloids belong to the most perplexing medical conditions, which have significant psychosocial impact on the patient's body image and quality of life. ***Summary:*** The article is purposed to provide dermatologists and plastic surgeons with the best proven practice using intralesional cryosurgery for the treatment of the different auricular keloid types in order to obtain superior clinical results by minimizing the probability of recurrence. In the past 20 years, the authors have developed novel procedures in order to increase the effectiveness of intralesional cryosurgery on auricular keloids, including hydrodissection, warm gauze technique, and excision of dangling skin. Long-lasting clinical results with a low recurrence rate and a satisfactory aesthetic outcome are achieved with no deformation of the ear framework.
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Introduction

Ear keloids are among the most perplexing medical conditions. They have significant psychosocial impact on the patient's body image and quality of life. Simplot and Hoffman [1] reported an incidence of auricular keloids following piercing of 2.5%. A possible cause is the development of chronic inflammation in the reticular dermis due to irritation by the metal particles [2]. Other less common causes for the development of ear keloids are elective surgery, trauma, and burns [3]. Various therapeutic options have been administered, such as intralesional injection of corticosteroids, verapamil, compressive therapy, laser and radiotherapy, surgical excision, anti-tumoral and immune-suppressive agents, and combination of these methods [4].

Intralesional cryosurgery has been shown to be effective in reducing the volume of auricular keloids with low recurrence rates [5–9] (Fig. 1). Cryosurgery of auricular keloids is a distinctive challenge due to the composite anatomy of the ear, from a delicate and adherent layer of

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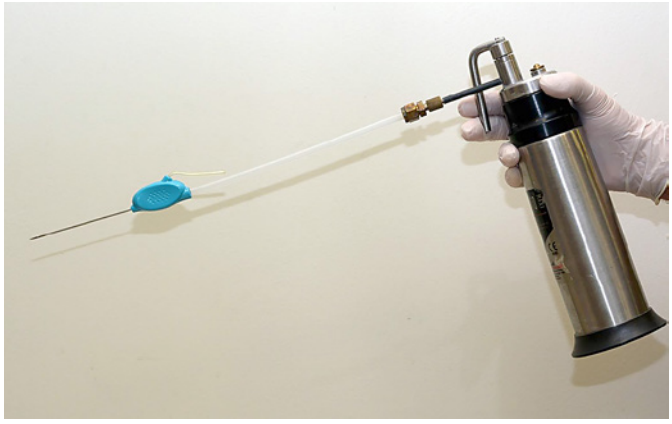

Fig. 1. The intralesional cryosurgery system composed of the cryoprobe needle connected to the cryogun.

Table 1. Different types of earlobe keloids [9] and their prevalence [10]

Type	Designation	Prevalence, %
I	Pedunculated (pedunculated type)	16
IA	Pedunculated anterior surface	
IB	Pedunculated posterior surface	
IC	Pedunculated both surfaces	
II	Sessile-single nodular pattern	51
III	Sessile-multinodular pattern	33
IV	Buried type	
V	Mixed type	

skin to the underneath cartilaginous skeleton to the lobule, which consists of a fat pad enveloped in thicker skin. Therefore, the treatment must be executed carefully to avoid damage to the healthy skin and the underlying cartilage.

Types of Auricular Keloids

Based on the Chang-Park classification [10], earlobe keloids are classified into 5 groups (Table 1). According to our clinical experience, keloids on the helix possess the same type variety as in the lobule. Chong et al. [11] have reported the gross prevalence of auricular keloid types in a study of 71 patients with 87 auricular keloids.

The aim of this work is to provide dermatologists and plastic surgeons with the best practical advice possibly leading to superior clinical results and minimizing the probability of recurrence when treating auricular keloids with intralesional cryosurgery.

Scientific Background

Thermal behavior measurements have been performed in an ex vivo swine muscle model during intralesional cryosurgery to explain the mechanism of action of the intralesional cryoprobe on keloidal tissue. Slow cooling (20 °C/min) and thawing (25 °C/min) rates, end temperature of –30 °C, 8 mm-wide diffuse coagulative-type necrosis and 3 mm-wide transition zone around the cryoprobe were detected [5]. A 67 ± 23% reduction of scar volume after a single session of intralesional cryosurgery was achieved in 10 auricular keloids after 1.5 years. Significant decrease in objective and subjective clinical symptoms was recognized [5–8]. Histomorphometric studies have demonstrated rejuvenation of the collagen fibers in the treated scar. A long (few minutes to hours) hold time (the duration of time the tissue is in the frozen state) in the core of the scar caused minimal damage to the melanocytes [7].

Recently, a newly developed biophysical model provided valuable data on the methodological procedure of intralesional cryosurgery on keloids [12]. The needle positioning of 1 cm towards the keloid basis ensures the clinical effectiveness, since the freezing zone does not exceed 1 cm to the healthy tissue. In addition, the needle should be optimally inserted at a distance of more than 1 cm away from the keloid surface, to prevent epidermal damage. In very large keloids, more than one needle should be used. In order to maximize effectiveness, needles should be arranged one over the other or one next to the other at distances of maximally 2 cm. Since the distal part of the needle induces a stronger freezing effect than the proximal one, entering the tissue from contralateral sites (parallel or crossed) will optimize the freezing effect [12].

Treatment Method

All described types and shapes of auricular keloids can be treated by intralesional cryosurgery. Most of these keloids have been previously treated by injection of corticosteroids, compression therapy, laser, radiotherapy, and surgical excision or by combination of these treatments with minor or no success. Previous treatments do not prevent the execution of intralesional cryosurgery.

The scar area is disinfected and draped with the patient lying in a prone position [8]. The scar is anesthetized locally by a translesional approach (Fig. 2), with bupivacaine hydrochloride 0.5% (Marcaine) or lidocaine

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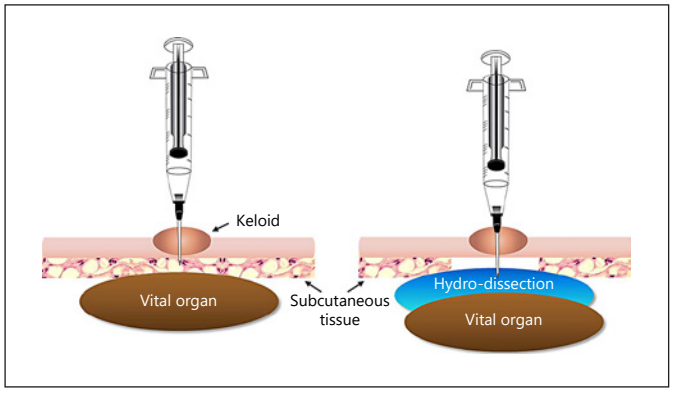

Fig. 2. Hydrodissection. Injury to the underlying cartilage (vital organ) can be prevented by infiltrating the tissue under the keloid and above the cartilage (left) with aesthetic solution or sodium chloride 0.9% in a translesional approach via the scar tissue (right). This method will disperse the ice ball from the underlying cartilage, thus preventing possible injury.

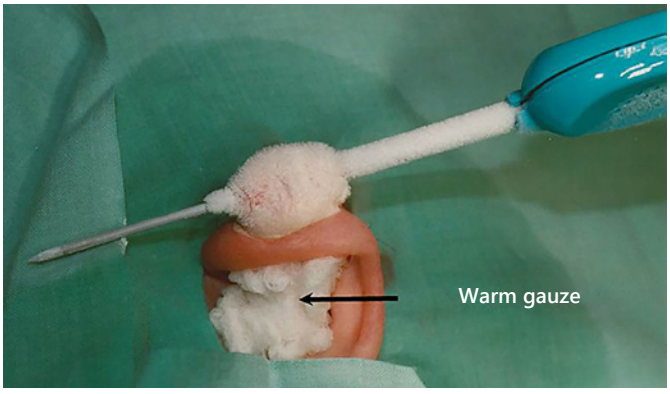

Fig. 3. Intralesional cryosurgery for the treatment of a posterior helical keloid (type IB). During intralesional cryosurgery, sterile warm gauzes are placed on the anterior helical aspect to prevent cryoinjury to the cartilage.

1%. In very large keloids, general anesthesia may be preferred. Thereafter, the cryoprobe (CryoShape, Life by Ice Ltd, Haifa, Israel) is introduced into the long axis of the scar core and parallel to the skin surface in a forward piercing movement [6, 12]. The scar is gripped by the other hand, until the sharp tip of the needle merges at the opposite pole of the scar without traumatizing surrounding healthy skin. Sterile gauzes are placed under the exposed parts of the cryoneedle (Fig. 3) and care is taken to assure that the vent nostril is positioned away from the patient to prevent unintentional freezing of adjacent normal skin.

The proximal elongation tube is connected to the cryogun (CryoPro Maxi 500 mL, Cortex Technology, Hadsund, Denmark, Fig. 1, or Cry-Ac B-700 500 mL, Brymill, Ellington, CT, USA), which is filled with liquid nitrogen about 15 min beforehand to 3/4 of the cryogun volume to allow the necessary working pressure to build up. A full pressurized cryogun can operate continuously for up to 45 min; therefore, small- to medium-size keloids can be treated without refilling the cryogun.

The cryogun is positioned higher than the scar to facilitate the liquid nitrogen to flow downwards. By activating the cryogun trigger, the cryogen flows into the cryoneedle, thereby freezing the scar. The liquid nitrogen or nitrogen vapor is never in direct contact with the patient skin during the intralesional cryosurgical procedure. During the entire freezing process, a strong steam of the liquid nitrogen gas drifts out from the vent which indicates a proper working pressure. Two ice balls appear shortly at the 2 cryoprobe penetration sites which gradually unify causing the whole scar to freeze, which can be observed by the naked eye. In addition, the freezing process is continued until a halo of about 5 mm beyond the scar margins is evident, which is needed to destroy the peripheral matrix metalloproteinase regardless of the length of the cryosurgery process. After the end of the procedure, the cryogun trigger is released and the freezing process is stopped. The cryoneedle thaws in 1–2 min and is pulled out. The duration of the intralesional cryosurgery process ranges between 5 min (small scar) and up to 3 h (giant bulky scar; Fig. 6, 9) and can be calculated prior to treatment by newly published algorithms [13]. The postoperative instructions are to rinse the wound daily and to apply an antibiotic ointment or a steroid cream on the blister and thereafter on the dry scab which will appear until complete healing is achieved. Necrosis of the entire keloid is expected due to the freezing of the keloid scar from inside out.

In cases where the scar is longer than 10 cm (which is the cryoneedle length) or wide, 2–3 parallel needles (Fig. 6, 9, 10) are required to facilitate the freezing of the whole keloid at once.

Possible side effects of the intralesional cryosurgery technique are: following thawing of the scar, slight self-limiting bleeding from the penetration points of the needle is noticed which usually stops spontaneously; blister formation which will drain after 7–10 days. A dry scab will appear after 10–14 days, which will eventually drop off and the underlying wound will heal. The healing time is in relation to the size of the treated keloid. The average time to complete healing is 45 days (range of 21–135 days

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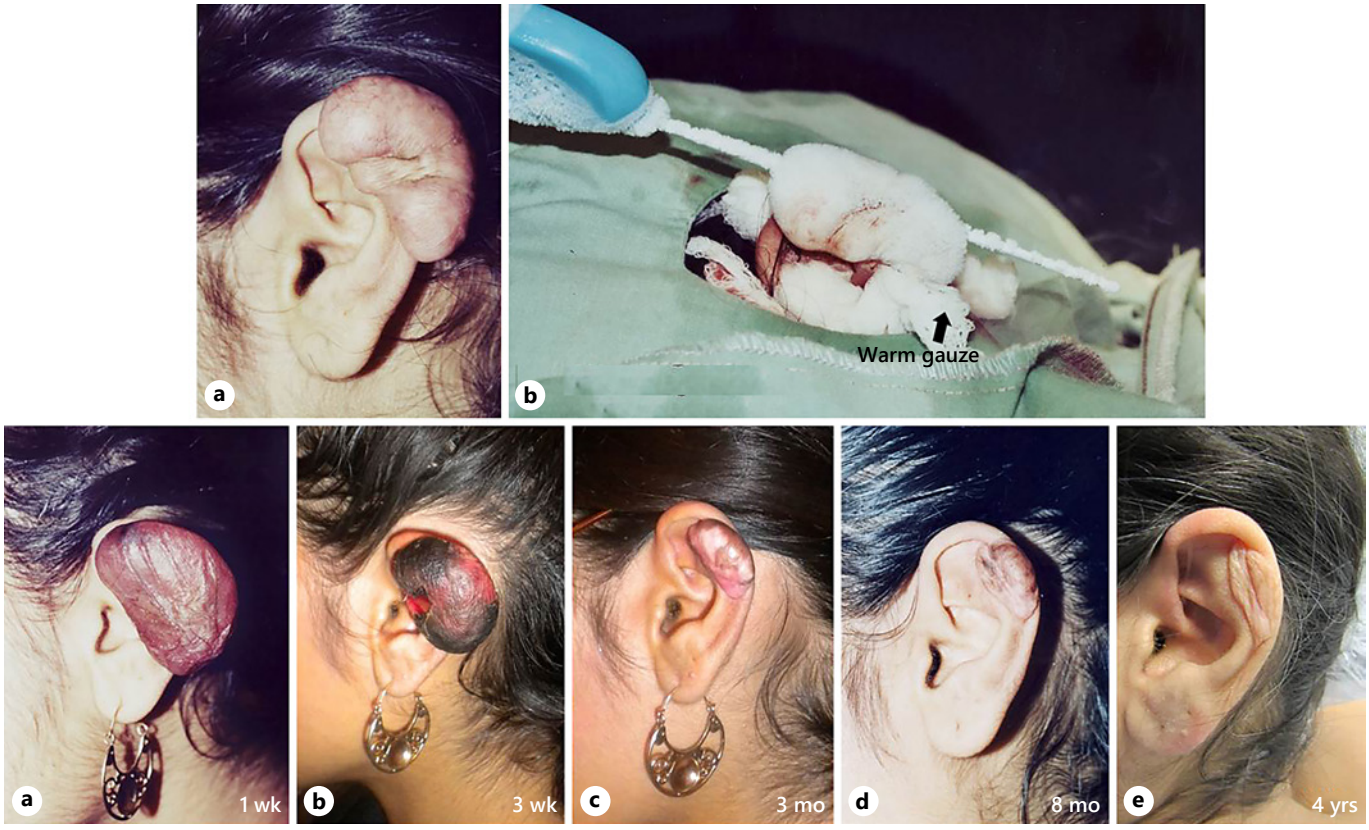

Fig. 4. Large keloid on the anterior left helix (type IA). *Top row.* **a** Preoperative view – a large keloid on the anterior left helix following piercing. **b** Complete freezing of the keloid is evident. Sterile warm gauzes (arrow) are placed to prevent cryoinjury to the cartilage. *Bottom row.* **a** One week postoperation, a blister is evident. **b** Three weeks postoperation, scar necrosis is evident. **c** Three months postoperation, the helical keloid has significantly downsized without distortion of the cartilage frame. Hypopigmentation is evident. **d** Eight months postoperation the scar is constantly reducing with repigmentation. **e** Four years postoperation, the helical keloid is flat with dangling skin. No recurrence or hypopigmentation is evident.

period) accordingly. In addition, pain, bleeding, and temporary oozing have been documented. Hypopigmentation was noted in every Caucasian or dark skin color patient with almost complete repigmentation in all cases at 1 year after treatment [6–8] (Fig. 4–11).

Results

Wright and O'Boyle [14] have published their UK experience with the intralesional cryosurgery technique treating 117 keloid scars in 68 cryosurgery procedures on 50 patients. Of these, 48% were located on the ear. The mean scar volume reduction was 83%. Har-Shai et al. [6] have treated 10 recalcitrant auricular keloids in 9 Caucasian patients by a single session of intralesional cryosurgery. An average of 67.4% reduction of scar volume was measured after 1.5 years. Significant reduction of hardness, elevation, and redness as well as itching, pain, and tenderness was documented [6].

A single intralesional cryosurgical session is usually needed to flatten the auricular scars. Less than 3% of cases have not responded to this procedure at the first attempt; thus, another one or two cryosurgical treatments were necessary. No infection, recurrence, or deformation of the ear framework has been documented (Fig. 4–11).

Practical Advice

General Procedures

Hydrodissection. In order to prevent injury to the underlying cartilage (vital organ) it is recommended to infiltrate the tissue under the keloid with sodium chloride 0.9% or with anesthetic solution and above the cartilage in a translesional approach via the scar tissue (Fig. 2). The

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Fig. 5. Large keloid on the posterior aspect of the right lobule (type II). **a** Following piercing. **b** 6 years following a single session of intralesional cryosurgery demonstrating a complete involution of the scar with no hypopigmentation. Sterile warm gauzes were applied on the lobule native skin during treatment to prevent the progress of the ice ball towards the normal lobule skin thus reshaping the lobule.

Fig. 6. Bulky keloid on the right lobule (type III) following piercing. **a** Four surgical excisions have been performed with complete recurrence of the keloid. During intralesional cryosurgery, sterile warm gauzes were applied to prevent the progress of the ice ball towards the normal skin of the upper lobule. One week (**b**) and 6 months (**c**) following the cryotreatment. **d** Two years after a single intralesional cryosurgery; a significant reduction of the keloid volume is evident with no recurrence.

hydrodissection method will disperse the ice ball from the underlying cartilage, thus preventing possible injury.

Warm Gauze. The cartilage is more resistant to permanent freezing injury than is the skin [15], and therefore perforation of the cartilage from cryogenic injury is unusual, even if freezing is carried through the entire thickness of the ear. Other authors warn about the potential of cartilage cryonecrosis when freezing auricular keloids [16, 17]. Burge et al. [18] have demonstrated experimentally and clinically, that auricular cartilage cryonecrosis is

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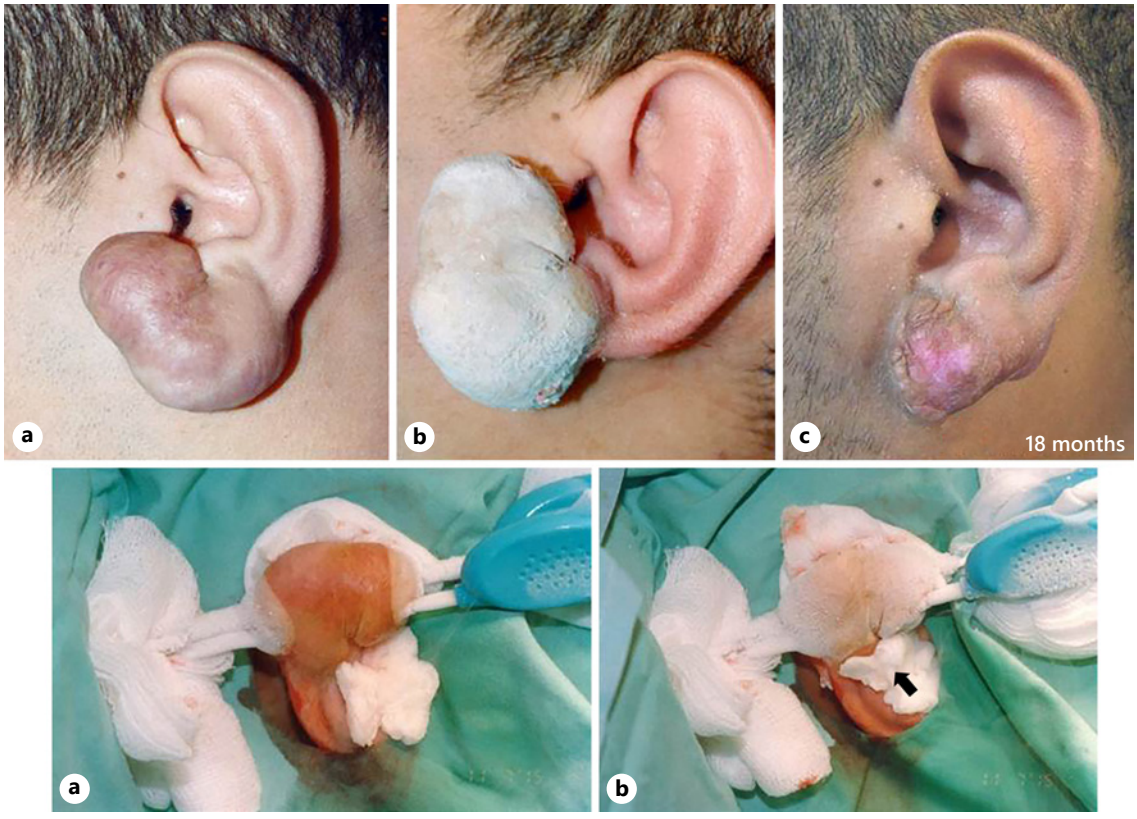

Fig. 7. Giant keloid on the left anterior lobule (type II). *Top row.* **a** Preoperative view. **b** Intraoperative view: complete freezing of the scar is evident with a halo. **c** 1.5 years after intralesional cryosurgery; the lobular keloid is flat with almost no hypopigmentation. No recurrence is detected. *Bottom row.* **a** Freezing is facilitated by 2 cryoneedles inserted in parallel. Two ice balls are evident at the penetration sites of the cryoneedles. **b** During the cryo-treatment sterile warm gauzes (arrow) were applied on the upper lobule native skin to prevent the progress of the ice ball towards the normal skin.

dose-related and is uncommon with the freezing times of maximum 30 s double freeze-thaw cycles.

Since the intralesional cryosurgery treatment can last from few minutes to over 3 h, the prevention of cryoinjury to the auricular cartilage is crucial. Therefore, the application of sterile warm gauzes (up to 30–40 °C) on the other side of the treated scar is fundamental to prevent cartilage injury (Fig. 3, 4). No injury or deformation of the auricular cartilage has been demonstrated following cryosurgical treated keloids with concomitant use of this safety measure. In addition, the auditory canal should be protected by inserting a Vaseline tampon during the treatment to prevent leakage of blood into the canal.

Specific Procedures (according to the Types of Auricular Keloids; Table 1)

Type I A-B. Although it seems clinically that in pedunculated keloids the freezing of the stalk of the keloid will suffice to cause complete destruction of the scar tissue, our clinical experience shows that following the freezing of the stalk only, partial necrosis of the keloid is evident. It is assumed that since the main tissue of the keloid is not affected by lethal temperature (–22 °C and lower), revascularization of the stalk occurs thus causing only incomplete necrosis. Therefore, complete freezing of the keloid including its stalk and a halo around the stalk is advocated. It is recommended to place sterile warm gauzes on the opposite side of the treated keloid as has been mentioned above (Fig. 3, 4).

Type I C. With pedunculated keloids on both surfaces, it is recommended to freeze each keloid separately. By freezing the 2 keloids simultaneously, the overlapping ice ball can injure the underlying cartilage especially when the cryosurgical treatment extends beyond 10 min. It is recommended to place sterile warm gauzes (up to 30–40 °C) on the intervening normal skin between the 2 ke-

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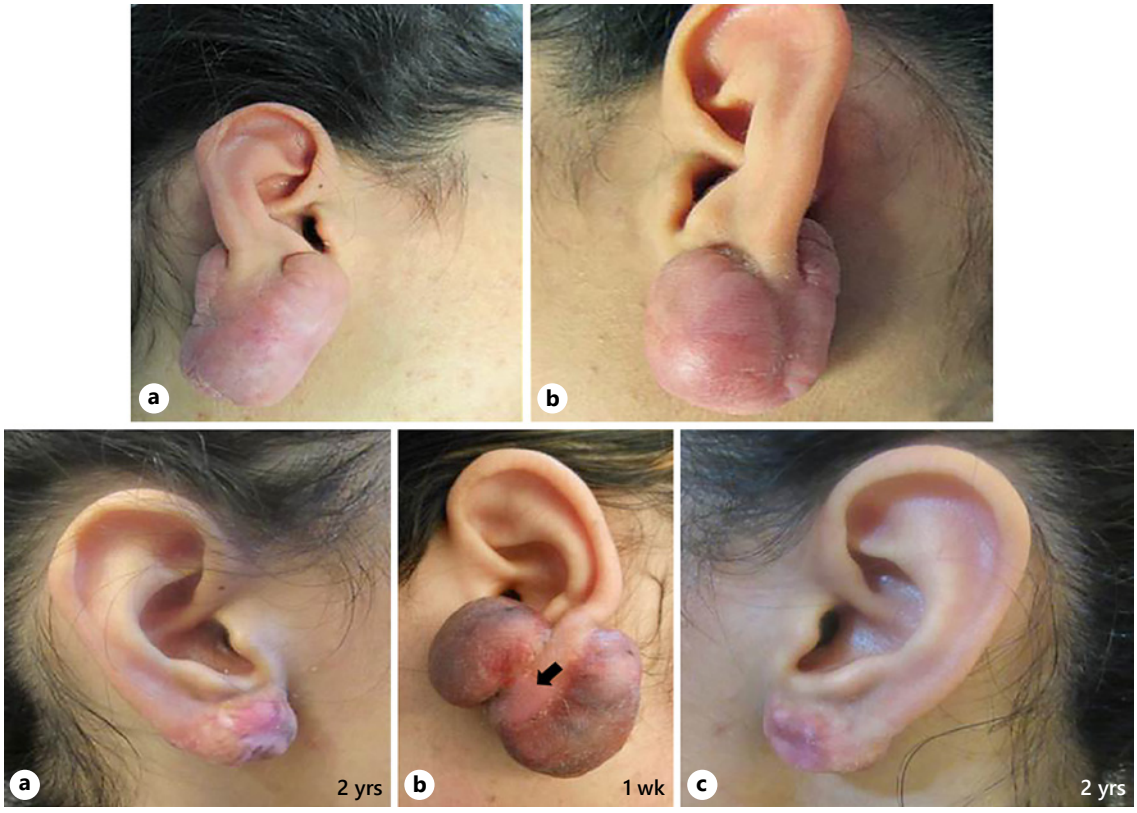

Fig. 8. Keloids located on both sides of the right and left lobules (type II). *Top row.* **a**, **b** Preoperative views. *Bottom row.* **a**, **c** Two years following treatment with intralesional cryosurgery. The lobular keloids are flat with almost no hypopigmentation. **b** One week postoperation, the upper pole of the lobule was not injured due to the application of warm gauzes between the 2 keloids during the cryosurgical treatment (arrow).

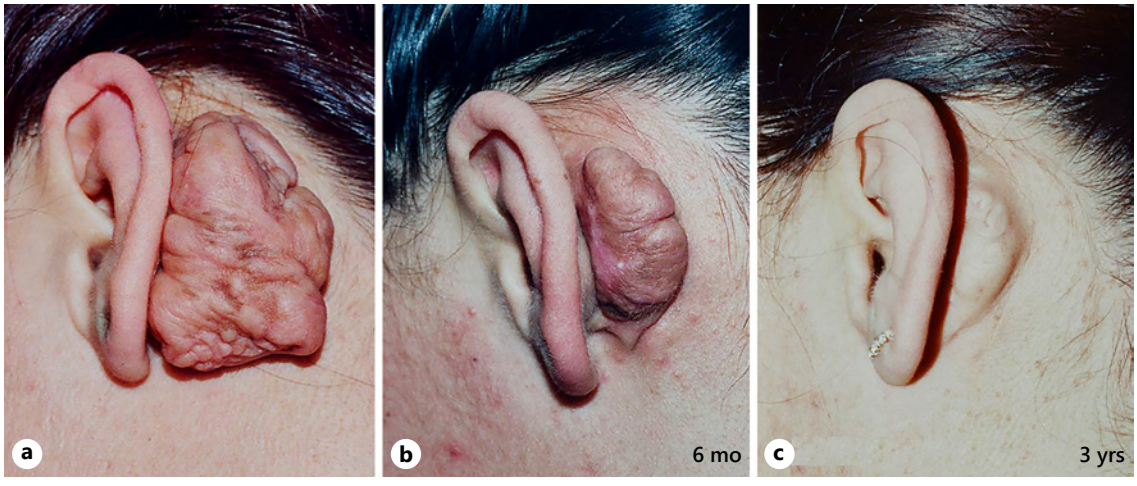

Fig. 9. a Pedunculated giant keloid on the left posterior auricular sulcus. **b** Six months following a single cryosurgical treatment, significant reduction of the scar is evident with an area of hypopigmentation. **c** Three years after the cryosurgical treatment, complete flattening of the scar is demonstrated with no recurrence or hypopigmentation.

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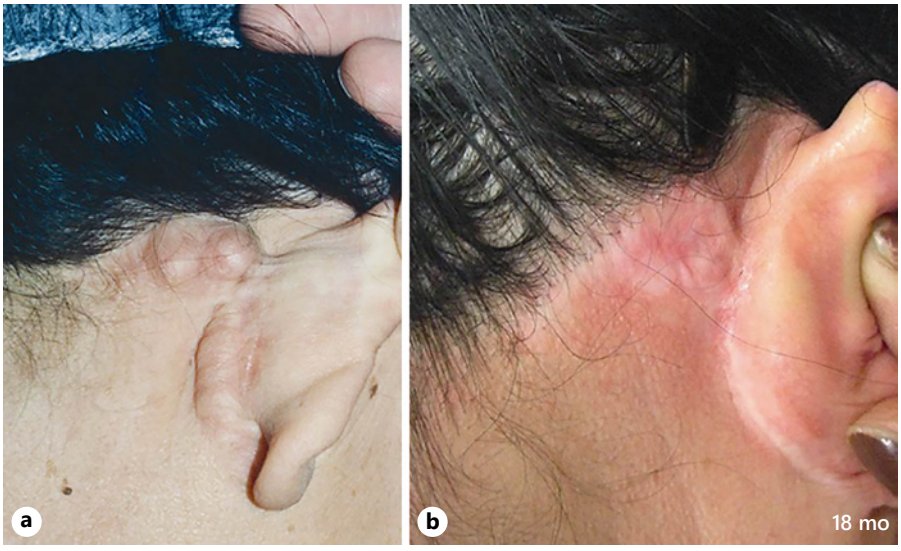

Fig. 10. a Multilobulated sessile keloids on the posterior auricular sulcus following cervico-facial lift. **b** One and a half years after a single cryo-session demonstrating a complete involution of the scar with no recurrence or hypopigmentation.

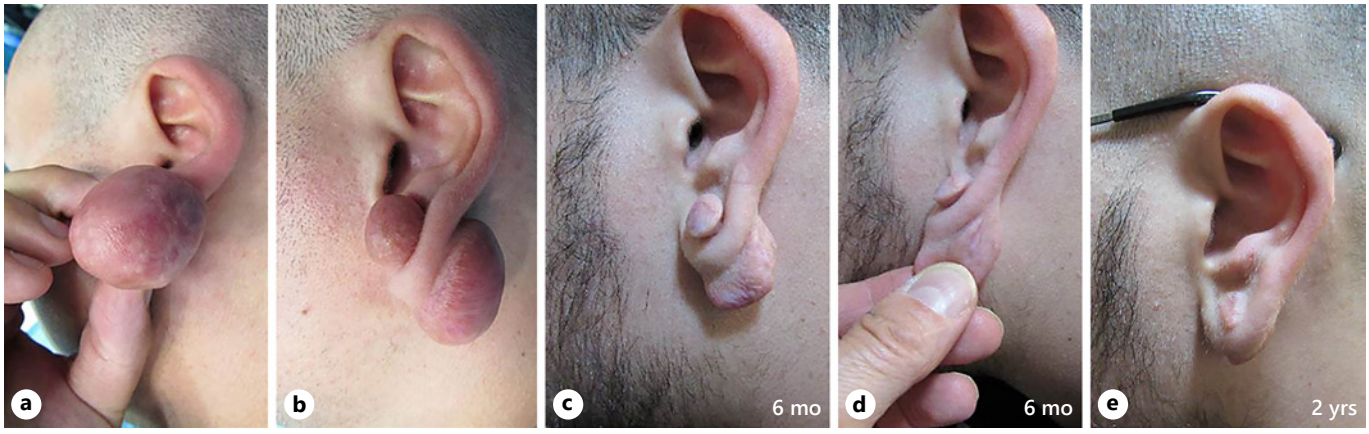

Fig. 11. Keloids located on both sides of the left lobule (type III). **a**, **b** Preoperative view. **c**, **d** Six months following a single cryosurgical treatment dangling skin with hypopigmentation is evident. **e** Two years after treatment with intralesional cryosurgery with remaining dangling skin, which was excised by an intralesional approach. No recurrence or hypopigmentation is evident.

loids to prevent injury to the normal skin and underlying cartilage.

Types II–III. These are the most common keloids of the ear. The base of sessile nodular keloids is usually wide (Fig. 5–8). Therefore, the freezing time is usually longer than pedunculated scars. In cases where the scars are very wide, 2–3 parallel needles are necessary to facilitate the freezing of the keloids in one session (Fig. 7).

When the keloid occupies part of or the entire lobule and the border between the lobule native skin and the keloids can be delineated, sterile warm gauzes are applied on the lobule native skin during the freezing process to prevent the progress of the ice ball towards the normal lobule skin. Thus, the tissue and shape of the native lobule can be preserved (Fig. 5–7, 11). In cases in which keloids are located on both sides of the lobule, a simultaneous cryosurgical treatment is advocated. It is recommended to place sterile warm gauzes on the intervening normal skin of the lobule during the procedure to prevent injury to the normal skin (Fig. 8).

Distinct Situations

Post-Auricular Keloids. These keloids usually develop following aesthetic surgery [19] (cervico-facial lift, otoplasty), reconstructive operations (mastoidectomy [9], cochlear implant [8]) or excision of benign or malignant

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skin lesions. Usually, the keloids are longitudinal in a multinodular pattern and are located in the post-auricular sulcus. It is recommended to insert the cryoneedle into all the scars by one passage and to freeze the keloids completely in one session (Fig. 10).

Dangling Skin. Following the successful eradication of the rubbery and firm keloid tissue, in some cases the remaining skin which covered the keloid remains dangling, thus it feels like an empty bag. Some patients are concerned about it and are seeking to remove this extra skin. There are 2 treatment possibilities: (a) Intralesional skin excision and suturing with nylon stiches without injuring the surrounding normal skin (Fig. 11), or (b) freezing the dangling skin by contact cryosurgery. The freezing process will cause the skin to shrink following healing.

Oversized and Therapy-Resistant Auricular Keloids. Intralesional excision combined with intralesional cryosurgery [20] are recommended. With oversized or therapy-resistant keloids on the ears, a method of intralesional excision of the scar followed by intralesional cryosurgery is recommended. The keloid is excised in an intralesional approach, and the remaining scar tissues are frozen using intralesional cryoneedles and sutured or vice versa; that is, the keloid is frozen, and after thawing the scar is excised using an intralesional approach and sutured.

Conclusions

The described practical advice during and following intralesional cryosurgery for the treatment of auricular keloids can help the surgeon to obtain superior clinical and aesthetic outcomes. The acquired results demonstrate a significant reduction in dissatisfaction among patients suffering from ear keloids [19].

Recently, new laser speckle contrast imaging [21, 22] has been introduced for the evaluation of skin perfusion in keloids. These technologies might help the surgeon to assess intraoperatively the extent of the expanding ice ball during the cryosurgical procedure.

The intralesional cryosurgery technique is an effective tool to reduce the dissatisfaction of patients with ear keloids and fosters a positive attitude towards the physician's efforts in bringing about a successful solution for their perplexing scars [19].

Intralesional cryosurgery can be performed to every shape and volume of auricular keloid and can be applied as an office procedure. In addition, it is safe to use, causes substantially less hypopigmentation [23, 24] when compared with contact cryosurgery, requires less cryogen fluid, has a short learning curve and is cost-effective [23]. Moreover, the cryoprobe can be connected to an existing cryogun of 500 mL.

Key Message

Intralesional cryosurgery can be applied to every type and shape of auricular keloids and can often be performed as an office procedure. It is safe to use, causes substantially less hypopigmentation than classical cryosurgery, requires less cryogen fluid, has a short learning curve and is cost-effective.

Statement of Ethics

For this kind of article, formal consent from a local Ethics Committee is not required.

Conflict of Interest Statement

Y.H.-S. has a financial interest in the intralesional cryosurgery technology. C.C.Z. has received honoraria with no relevance for the manuscript presented from Almirall, Galderma, GSK/Stiefel, Incyte, InflaRx, Janssen, Pierre-Fabre, PPM, Regeneron, UCB. His departments have received grants from AbbVie, Celgene, Inflarx, NAOS-BIODERMA, Novartis, PPM Relaxera, and UCB for his participation as clinical investigator. L.H.-S. and V.A.Z. have no conflicts of interest to declare.

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Author Contributions

Y.H.-S. and C.C.Z. study design; Y.H.-S., L.H.-S., V.A.Z., and C.C.Z. preparation and revision of the manuscript.

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