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The role of Botox in scar treatment: A comprehensive review

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Abstract

Botox is a neurotoxin which is widely used for cosmetic and therapeutic applications. Recently, it has shown promise in the treatment of hypertrophic and keloid scars. This review aims to examine the current literature to assess the efficacy of Botox in managing scars. Its mechanism of action centers on reducing the tension exerted on healing wounds by underlying muscles. This reduction in tension is crucial because excessive muscle movement can disrupt the delicate process of tissue repair, potentially leading to wider, more noticeable, or hypertrophic scars. Other mechanisms include inhibition of fibroblast activity and decreased collagen production. In addition, it reduces the expression of inflammatory markers. In conclusion, Botox is a safe and effective non-invasive treatment for hypertrophic scars, keloids as well as post-surgical scars. However it is ineffective in other types of scars.

Keywords: Botulinum toxin; Hypertrophic scars; Keloids; Neurotoxin; Surgical wound

1. Introduction

Botox, officially known as botulinum toxin type A, is a neurotoxin produced by the bacterium Clostridium botulinum. While this toxin results in botulism when taken in large amounts, in highly diluted and purified form, it is used in both cosmetic and therapeutic treatments. Seven distinct serotypes exist (botulinum neurotoxin type (BoNT)A through G). However, only two serotypes-type A and B-are significant for therapeutic use [1, 2].

Botox works by interfering with the release of acetylcholine, a neurotransmitter crucial for muscle contraction [3]. The reduction in acetylcholine leads to decreased muscle contraction [4]. The paralytic effects of Botox injections typically become noticeable within 24 hours to two weeks after treatment. The duration of this muscle relaxation is generally three to six months, after which the treated muscles gradually regain their normal function as the nerve fibers regenerate [5]. The exact time frame can vary based on individual factors like metabolism, the specific Botox product used, the injected muscle group, and the dosage administered [6].

Botulinum toxin (Botox) is used for both cosmetic and therapeutic applications. Cosmetically, it's primarily used to reduce the appearance of wrinkles, particularly in the upper face, and lift eyebrows [7, 8]. Its therapeutic application include effective treatment of hyperhidrosis and management of certain skin conditions like acne and eczema[7]. Medically, it also addresses a broad range of conditions, including various head and neck disorders (such as dystonias and temporomandibular joint disorders), chronic migraines, urinary incontinence, facial pain syndromes, and even voice and speech disorders [9].

Scars are fibrous tissues that replace normal tissues during wound healing. This process occurs in three distinct phases: an initial inflammatory phase involving clotting and immune response; fibroplastic phase marked by fibroblast

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proliferation and collagen production; and a remodeling phase where collagen fibers mature and reorganize, strengthening the scar [10].

Scars are classified into several types depending on their appearance, cause and location. Based on appearance, scars are mainly categorized as hypertrophic, keloid, or atrophic. Wound healing produces a range of scar outcomes, from inconspicuous to pathological. Abnormal scarring encompasses a spectrum of conditions, including stretched, depressed, or contracted scars, as well as raised scars like hypertrophic and keloid scars. The latter is characterized by excessive extracellular matrix (ECM) production during healing and may have a genetic component. While both are raised, keloids uniquely extend beyond the original wound and fail to regress [11, 12]. Skin scars can significantly diminish quality of life by causing physical discomfort (pain, itching, tightness), negatively affecting body image and self-esteem, hindering social interactions due to perceived unacceptability, and leading to emotional distress such as anxiety or depression [13].

This review article aims to comprehensively evaluate the emerging evidence of the use of botulinum toxin (Botox) in scar management. The objectives are to summarize existing research investigating the efficacy and safety of Botox in various scar types and to analyze proposed mechanisms of action.

2. Mechanism of action

Botox has multiple mechanisms in reducing the appearance of scars. The first mechanism is by reducing the tension on the healing tissues. Botox injections cause muscle relaxation by interfering with the communication process between nerves and muscles. The toxin initially attaches to receptors on the presynaptic nerve terminals at the neuromuscular junction. Following attachment, the Botox molecule is taken up into the nerve ending through endocytosis [14]. Inside the nerve ending, the active part of the toxin, selectively cleaves specific soluble N-ethylmaleimide-sensitive attachment protein receptor (SNARE) proteins such as SNAP-25 that are crucial for the release of acetylcholine, a neurotransmitter that triggers muscle contraction. Acetylcholine vesicle fusion with the nerve membrane will be disrupted, thereby preventing the release of acetylcholine into the synaptic cleft. This prevents the signal for muscle contraction from reaching the muscle fibers, resulting in temporary muscle paralysis [15]. This lessens the tension on healing tissue by preventing microtraumas caused by repeated, small muscle contractions. This reduction in tension is crucial because prolonged tension around a wound prolongs the inflammatory phase, directly contributing to the development of hypertrophic scars [16].

Botox is also capable of inhibiting the release of major pro-inflammatory cytokines and reducing the expression of markers of inflammation. it reduces the level of mast cells and the expression of IL-4 and TGF-β. consequently, it influences the effect of inflammatory scars. Botox acts as a muscle relaxant and modulator of a profound inflammasome present in the inflammatory infiltrate. This dual mechanism represent advantages for its use in infected wound healing or in seriously compromised patients [17].

Another role of Botox is the inhibition of fibroblast activity, as their excessive collagen production is believed to be responsible for hypertrophic and keloid scars. Fibroblasts are fundamental cells that produce type I and III collagen fibers during wound maturation, which contributes to the formation of scars. Therefore, a decrease in fibroblast activities have potential implications for scar maturation, including appearance and texture. Studies have demonstrated that treatment with Botox leads to reduced scar size, thickness, and redness, which appears to be achieved by decreasing the number of fibroblasts and collagen deposition, while potentially targeting abnormal fibroblasts specifically [18, 19].

3. Applications of Botox in scar treatment

3.1. Botox for the treatment of Hypertrophic scars and keloids

Several studies investigated the effectiveness of botulinum toxin type A (Botox, BTX-A) in treating facial hypertrophic scars. The results showed that patients receiving Botox injections experienced statistically significant improvements compared to a control group. Specifically, the Botox group had lower Visual Analog Scale (VAS) scores which indicates less pain, lower Vancouver Scar Scale (VSS) scores indicating better overall scar appearance, and narrower scar widths. These findings strongly suggest that Botox is effective in reducing pain, preventing excessive scar growth (hypertrophy), and minimizing scar widening [20].

Clinical studies on Botox treatment for keloids have also demonstrated substantial improvements in various aspects of keloid appearance and patient experience. Significant reductions in keloid volume (up to 82.7%), height, and redness

have been observed [21]. Furthermore, patients reported significant relief from associated symptoms such as pain and itching. The treatment's effectiveness is underscored by high patient satisfaction rates, with some studies reporting excellent outcomes in 75-100% of participants [22, 23]. Encouragingly, long-term follow-up in some cases revealed no signs of keloid recurrence even one year after treatment completion, suggesting the potential for durable results [23].

Botox treatment for scars typically involves injections of 20 to 100 International Units (IU) per session, with the specific dose determined by the scar's size and location. Treatment typically consists of multiple sessions, spaced 2 to 3 months apart, for a total treatment duration of 6 to 9 months. For optimal results, Botox is often used in conjunction with other scar treatment modalities, such as intralesional steroid injections or the application of topical agents. This combined approach aims to maximize scar improvement by addressing different aspects of scar formation and appearance [24].

Futhermore, a study comparing Botox, a steroid (triamcinolone), and their combination for hypertrophic scars using a mouse model demonstrated that while all treatments improved scar tissue, the combined Botox and triamcinolone therapy was most effective, significantly reducing scar weight and fibroblast proliferation more than individual treatment groups. This suggests that Botox combined with steroid is superior to using either drug individually [25].

3.2. Botox for Post-surgical scars

Botox, is used to enhance post-surgical scar healing, especially in cosmetically sensitive areas like the face and neck area. The application of Botox in post-surgical scar management spans various surgical specialties [26]. In facial surgery, it's frequently employed following procedures like facelift, blepharoplasty, and mole excisions to minimize the risk of widened scars in these highly visible areas [27]. Its benefits extend to reconstructive surgery, particularly in regions prone to significant movement, such as around joints or in areas subjected to high tensile forces. A study found that patients who received 50 units of Botox injected into the platysma muscle during surgery had significantly better scar outcomes compared to a control group. This improvement was consistently observed at 1, 12, and 24 weeks post-surgery, as measured by both the modified Stony Brook Scar Evaluation Scale (SBSES) and the Manchester Scar Scale (MSS). The results demonstrate improved cosmetic results following thyroidectomy [28].

The Botox injections are typically administered soon after surgery, ideally within the first few weeks of the healing process, while the scar is still forming [29]. Small doses of Botox are precisely injected into the muscles surrounding the surgical site, strategically targeting those muscles that contribute most significantly to wound tension. The effects of a single Botox injection are temporary, typically lasting 3 to 6 months, necessitating repeat injections to maintain the beneficial effects throughout the critical healing period. This phased approach allows for sustained reduction of muscle tension and promotes optimal scar healing over time [30].

Furthermore, Botox can be beneficial in managing trauma-related scars, reducing the likelihood of the scar becoming excessively thick, raised, or irregularly shaped. Early injection, within the first few weeks after injury or surgical repair, is key to its effectiveness. Botox is injected into the muscles surrounding the scar, with the dosage and precise injection points tailored to the scar's size, location, and the activity of the surrounding muscles [31].

4. Advantages of Botox for scar treatment

Botox is a non-invasive treatment option that effectively improves scar appearance, which makes it a convenient option for patients. Besides, its effects are prolonged, typically lasting for several months.

Numerous studies have demonstrated Botox treatment to being effective in improving scar appearance and reducing associated symptoms like pain and itching, and these studies consistently report a low incidence of adverse events. The risk of serious systemic effects is minimal at therapeutic dosage [32-34]. While mild, temporary side effects like redness, swelling, bruising, or localized pain at the injection site are possible, these usually disappear within a few days. More serious side effects, such as muscle weakness spreading beyond the injection site or allergic reactions, are extremely rare. However, it's crucial that the injections are administered by a qualified and experienced healthcare professional who understands the proper injection techniques and dosage regimens to minimize the risk of complications [35].

5. Limitations of Botox for scar treatment

Although Botox injections are effective for some scars, it can't be used to treat other kinds of scars like atrophic scars, ice pick, or hyperpigmented scars. The treatment is only limited to hypertrophic, keloid and some post-surgical scars.

Furthermore, the results are temporary, typically lasting only a few months. It requires repeated injections to maintain the treatment effect, leading to ongoing costs and commitment. Botox primarily affects scar height and tightness, leaving texture and color largely unchanged. Consequently, other treatments may be necessary for comprehensive scar improvement. Finally, Botox is rarely a standalone solution. Optimal results often require combination therapy with other treatments. The cost of multiple treatments can be substantial, making it inaccessible to some patients.

Large-scale studies are needed to determine the effectiveness of Botox as an individual treatment in combination with other therapies, for hypertrophic scars and keloids.

6. Conclusion

The use of Botox for treatment of scars seems to provide several advantages, including a significant decrease in scar size and a notable reduction or prevention of hypertrophic scarring. This non-surgical treatment for hypertrophic and keloid scars has proven to be both safe and highly efficient. However, it is important to note that additional researches are needed in order to further understand its role.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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