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Original Article

Auxiliary rehabilitation training after calf contouring with botulinum toxin type A injection reduces adverse reactions and improves satisfaction

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Abstract: Purpose: To analyze the effect of adjuvant rehabilitation training after calf contouring with botulinum toxin type A (BTX-A) injection. Methods: Clinical data of 48 female beauty seekers who underwent calf contouring at the Plastic Surgery Laser Center of Guangdong Second People's Hospital from January 2021 to June 2022 were retrospectively analyzed. Among them, 24 cases received routine care from January 2021 to December 2021 and were included in a control group, and 24 cases received rehabilitation care with auxiliary rehabilitation training from January 2022 to June 2022 that were in an observation group. The subjects were followed up for 24 weeks to observe the curative effect, and the injection efficacy was compared between the two groups. The maximum calf circumference (MCC) and gastrocnemius muscle thickness (GMT) were comparatively analyzed before and 2, 4, 12, and 24 weeks after treatment. The incidence of adverse reactions and satisfaction rate were also compared. Results: Both groups showed reduced calf circumferences after injection, with soft and uniform calf curves. No intergroup statistical significance was identified in terms of curative effects. Reduced MCC and GMT were observed in both groups at 2, 4, 12, and 24 weeks after treatment, with lower values in the observation group than in the control group at week 2, 4, and 12. The observation group also showed markedly fewer adverse reactions and higher satisfaction rate than the control group. Conclusions: BTX-A injection is effective in calf contouring and can significantly reduce the MCC and GMT. In addition, post-injection rehabilitation training can significantly reduce the occurrence of adverse reactions and improve patient satisfaction.

Keywords: Botulinum toxin type A, calf contouring, rehabilitation training, degree of satisfaction

Introduction

Advances in plastic surgery are usually achieved by applying existing principles and techniques to problems or areas of the body that have not been previously considered [1]. As living standards improve constantly, there is an increasing demand among individuals to enhance their physical appearance, especially the exposed calves that have received increasing attention among young women. The criteria for charming legs are not only based on fat or thin alone, also the shape of the legs [2]. A study has shown that plump and muscular calves, the so-called "radish legs", make young women feel embarrassed and inferior in South Korea [3]. In Asia, the concept of physical attractiveness is usually associated with having a pair of pretty legs, which explains the increasing demand for calf plastic surgery in the market to obtain slender legs and ideal curvature [4]. A charming leg curvature involves the alignment of the bones, the smooth muscle lines, and the symmetry of the circumference of the thighs and calves [5]. Benslimane et al. [6] described the concept of a "perfect" calf shape. However, as the concept of beauty remains a subjective perception, the aesthetic requirements of Western and Asian women vary widely. As for calf beauty in Western women, Mundinger et al. [1] pointed out that slender calves are unsightly, which we believe is the cause of the appearance of "pseudo-varus" calves. Tsai et al. [7] argued that Asian women prefer calves with straight inside lines. In the Asian beauty market, leg protrusion or gastrocnemius hypertrophy is considered as an obstacle to calf beauty.

Table 1. General information

Groups	Control group (n=24)	Observation group (n=24)	t	P
Age	27.94±5.99	27.22±3.49	0.5088	0.6133
Maximum calf circumference (cm)	36.27±1.25	36.39±1.34	0.3208	0.7498
Gastrocnemius muscle thickness (cm)	1.85±0.35	1.86±0.30	0.1063	0.9158

As a result, some people choose to use interventions to achieve a perfect calf shape. With the increasing trend of reducing calf protrusion in the Asian market, aesthetic calf surgery has quickly become the new favorite of many beauty seekers [8]. With advancements in medical technology, various treatments are available for calf reconstruction, but the appropriate treatment choice should be based on the specific nature and underlying factors contributing to calf protrusion. Given that some methods are high-risk surgical schemes with high probability of complications [9], non-invasive technologies are widely recognized and accepted. Among them, botulinum toxin type A (BTX-A) injection for calf contouring is a highly desirable treatment option due to its ability to promote calf muscle atrophy and improve calf shape. This approach is favored for its minimal invasiveness, quick recovery and favorable outcomes [10].

BTX-A, a neurotoxin produced by the anaerobic bacterium Clostridium botulinum [11], was approved by the US Food and Drug Administration in 2002 to temporarily reduce glabellar frown lines in patients aged 65 and under, and is now widely used for cosmetic purposes, such as plethora, body contouring, and other non-invasive facial surgery [12, 13]. It can selectively act on peripheral cholinergic nerves, inhibit the release of acetylcholine from the presynaptic membrane and block the transmission of neurotransmitters at the neuromuscular junction (i.e., synapses), thus inducing muscle flaccid paralysis and local muscle disuse-atrophy and achieving good shaping effects [14, 15]. Nevertheless, there is no relevant research report on the role of auxiliary rehabilitation training in calf contouring after BTX-A treatment. Consequently, the purpose of this study was to compare the effects of routine care and auxiliary rehabilitation training after receiving BTX-A injections for calf contouring.

Methods

Case selection and ethical approval

The clinical data of 48 female beauty seekers who received calf contouring at the Plastic Surgery Laser Center of Guangdong Second People's Hospital between January 2021 and June 2022 were collected and retrospectively analyzed. The included cases all met the following criteria: (1) females with simple calf muscular hypertrophy; (2) females without contraindications for botulinum toxin injection; (3) females with complete follow-up information and clinical data. Exclusion criteria: (1) those who need to run and stand on tiptoe for a long time; (2) those suffering from mental illness or who were too demanding of the injection effect; (3) those who were allergic to BTX-A or over-dependent on botulinum toxin; (4) those with infection at the intended injection site; (5) those with neuromuscular conduction disorders; (6) those with hematological or infectious diseases; (7) those who had aminoglycoside antibiotics, magnesium sulfate, cholinesterase antagonists within the recent 14 days; (8) pregnant or lactating women or those who were planning pregnancy; (9) those with incomplete clinical data. Among the included 48 subjects, 24 cases received routine care from January 2021 to December 2021 which were included in a control group, and 24 cases received rehabilitation care with auxiliary rehabilitation training from January 2022 to June 2022 that were in an observation group. The general data of the two groups are shown in **Table 1**, with comparability between the two groups. The ethics committee of Guangdong Second People's Hospital has approved this study.

Nursing methods

(1) Pre-injection assessment was performed on all subjects, and only those with muscular calves [16] were included to receive BTX-A

injection for calf contouring. The beauty seekers were asked about their medical history, drug use, allergies, and previous history of minimally invasive plastic surgery injections, as well as their expectations. Preoperative comparison photos were taken and kept as medical records. After photographing, compound lidocaine cream (Beijing Soft-world International Corporation), which can effectively relieve injection pain, was applied locally.

(2) Preoperative design and BTX-A injection were then performed. Injection methods: Grid lines were drawn 2.0 cm apart on the calves of the subjects, and the intersection points were the injection points, with about 30-33 points/side. BTX-A (Hengli, Lanzhou Institute of Biological Products Co., Ltd., 100 U/pcs) was injected into the calves, at a concentration of 2 U/0.1 mL after dissolution and dilution with 5 mL normal saline. Half an hour before injection, lidocaine cream was evenly applied to the local skin to reduce injection pain, with the dosage selected according to the calf muscle condition. Dosage principle: For a calf circumference (CC) >37 cm, 32-37 cm, and <32 cm, BTX-A was injected at a dose of 200 U per side, 150 U per side, and 100 U per side, respectively. First of all, the subjects were asked to lie prone and relax her calf muscles. After strict disinfection of the injection area with 2% iodophor, a 1 mL syringe was connected with a 30G needle to insert vertically for intramuscular injection. There were 10 injection points on the medial head of gastrocnemius muscle to eliminate tough lines, 10 injection points on the soleus muscle to reduce the CC and inhibit compensatory hypertrophy of soleus muscle, and 20 injection points on the lateral head of gastrocnemius muscle to smooth the curve of the calf. After injection, anti-inflammatory ointment was applied to the injection points. The subjects were required to stay in hospital for a 20-min observation and could be discharged if there was no discomfort. Post-injection precautions: According to the Consensus Recommendations on the Aesthetic Usage of BTX-A [17], the subjects were advised not to run fast or violently within 2 months after calf injection with BTX-A, because the decreased calf muscle contractility after gastrocnemius injection may affect coordination during running. They were also asked not to massage or rub the injection area, take aminoglycoside antibiotics (e.g., gentamicin and tobramycin), or do strenuous leg exercises within 2 months, such as long run and ballet dance.

(3) All participants were given routine care after the injection. Those in the observation group received the following auxiliary rehabilitation training on the basis of routine care.

① Establishing a nursing team: According to the work status and staff structure of the department, a nursing team was established with a senior charge nurse as the team leader, and the tasks and responsibilities of the team members were clearly defined.

② Constructing files: Hospital customer relationship management and patient information database were constructed. The data included patient's basic identity information, education, occupation, family income, social preference, medical and aesthetic history. Personalized services and integrated medical and nursing care services were provided. In addition, the traditional dominant subordinate dependency relationship between doctors and nurses was transformed from conduction to a juxtaposition, merging and complementary doctor-patient relationship. The responsible nurses and doctors participated in the whole process. The nurse-in-charge actively participated in the entire treatment process, including face-to-face consultations, treatment program design and patient care. The doctor and nurse work collaboratively to create a supportive medical environment, optimizing the overall care process for the patients. Moreover, one-on-one instruction on the correct rehabilitation training method was provided after injection. In addition, we ensured comprehensive follow-up care by maintaining continuous communication with patients through social media, urging patients to adhere to the rehabilitation training, providing emotional support, and keeping updated on patients' progress and needs.

③ Rehabilitation training contents: On-site one-to-one guidance was provided to the subjects to ensure they were instructed in the correct method of post-injection rehabilitation training. The subjects in the observation group were also instructed to do low-intensity aerobic exercise (slow walking, yoga, etc.), stretch their calves frequently, and do less explosive exer-

Table 2. Comparison of therapeutic effects between the two groups

Groups	Injection dose (pcs)	Effective (n)	Ineffective/ poor effect (n)
Control group (n=24)	2.25±0.53	22 (91.7)	2 (8.3)
Observation group (n=24)	2.38±0.58	24 (100.0)	0 (0)
χ^2/t	0.8106	2.0871	
P	0.4218	0.1486	

cise (long running, dancing, ballet, etc.). Dorsal stretching training was performed 6 sets/day, 30 times/set. They were also trained with air walking and roller stretching after treatment, 3 sets a day, 2 minutes per set. In addition, the calves were evenly smeared with olive oil and massaged for 5 minutes, after which the calves were wrapped tightly with plastic film for 30 minutes, once every two days, aiming to burn superficial fat and shaping lines.

Outcome measures

(1) The therapeutic effect was compared between the two groups. Markedly effective meant that significant changes were observed in relevant indicators (maximum calf circumference, MCC; gastrocnemius muscle thickness, GMT) after treatment, while poor effects or ineffective meant the absence of significant changes, compensatory hypertrophy of soleus muscle, and poor injection effects.

(2) Calf appearance: Photos were taken before and after treatment, and the calf appearance was compared before and 12 weeks after treatment. Changes in gastrocnemius muscle appearance were also observed.

(3) MCC: MCC was measured before and 2, 4, 12, and 24 weeks after treatment.

(4) GMT: GMT was measured by ultrasound before and 2, 4, 12, and 24 weeks after treatment.

(5) Adverse reactions: 1) weakness and cramps: weakness refers to asthenia of the calves after long-term fast walking or running, which was gradually alleviated after rest; cramps only lasted for 1-2 months, which did not affect daily activities or require special treatment; 2) edema: the subjects reported edema of legs after injection, and the calves were swollen more easily in the afternoon than in the morning; 3) muscle tenderness in both legs: muscle soreness was also one of the common adverse reactions, and some participants reported increased pain during walking.

(6) Satisfaction: A self-made satisfaction questionnaire was used to investigate patient satisfaction. By telephone follow-up or revisits, the satisfaction of subjects was investigated anonymously with a 100-point scoring questionnaire. The survey contents included nursing methods, service attitude, communication skills, and therapeutic effects, with a score of >90, 80-90, and <80 indicating satisfied, basically satisfied, and dissatisfied, respectively. Total satisfaction = (satisfied + basically satisfied) cases/total cases *100%.

Statistical methods

This study employed SPSS 20.0 and GraphPad Prism 8.0 for data analysis and visualization, respectively. Described as mean ± standard deviation, the measurement data were tested by the t test. The counting data were represented by cases (percentages), and the chi-square test was used for the comparisons. A minimum significance level of $P<0.05$ was set.

Results

Therapeutic effects of the two groups

The two groups were not statistically different in injection dosage ($P>0.05$). In the control group, effective treatment and ineffectiveness/ poor effects were found in 22 cases and 2 cases, respectively, while all the 24 cases in the observation group reported effective treatment. No significant difference was found in the number of cases with effective treatment between the two groups ($P>0.05$), as shown in **Table 2**.

Observation of calf appearance in the two groups

After follow-up, all the 48 participants had reduced CC, and the curve of the lower leg was soft and uniform. The comparison of calf appearance before and 12 weeks after treat-

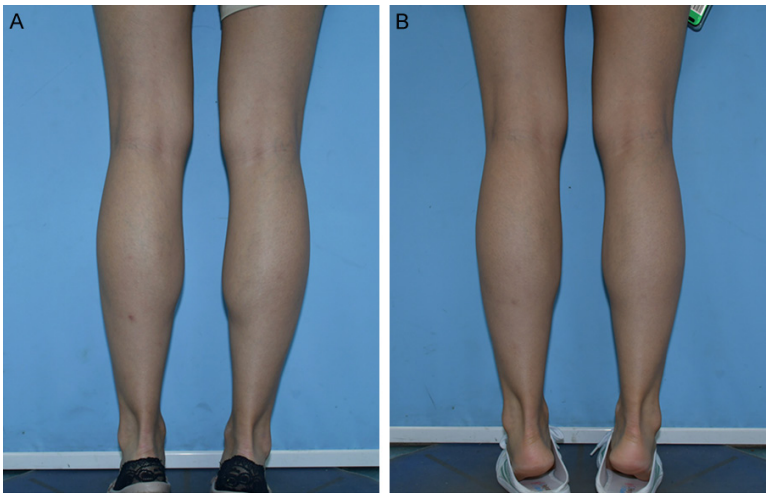

Figure 1. Comparison of calf appearance before and after treatment in a typical case in the observation group. A: Calf appearance before treatment; B: Calf appearance 12 weeks after treatment.

Table 3. Comparison of maximum calf circumference between the two groups (cm)

Groups	Control group (n=24)	Observation group (n=24)	t	P
Before injection	36.27±1.25	36.39±1.34	0.3208	0.7498
2 weeks after injection	34.99±1.20*	34.22±1.14*	2.2791	0.0273
4 weeks after injection	33.69±1.11*	33.10±0.98*	2.0227	0.0489
12 weeks after injection	32.95±1.17*	32.21±1.12*	2.2383	0.0301
24 weeks after injection	34.29±1.27*	34.18±1.25*	0.3024	0.7637

Note: *P<0.05 vs. before injection in same group.

Table 4. Comparison of gastrocnemius muscle thickness between the two groups (cm)

Time point	Control group (n=24)	Observation group (n=24)	t	P
Before injection	1.85±0.35	1.86±0.30	0.1063	0.9158
2 weeks after injection	1.69±0.19*	1.59±0.15*	2.0237	0.0488
4 weeks after injection	1.55±0.21*	1.44±0.16*	2.0411	0.0470
12 weeks after injection	1.49±0.19*	1.40±0.10*	2.0535	0.0457
24 weeks after injection	1.67±0.22*	1.60±0.15*	1.2879	0.2042

Note: *P<0.05 vs. before injection in same group.

ment in a typical case in the observation group is shown in **Figure 1**.

MCC in the two groups

Before treatment, the MCC of the control and observation groups were (36.27±1.25) cm and (36.39±1.34) cm, respectively. At 2, 4, 12, and 24 weeks after treatment, the MCC was reduced in both groups (P<0.05). In addition, the observation group showed smaller MCC than the control group at the 2nd, 4th, and 12th weeks after injection (P<0.05), as shown in **Table 3**.

GMT of the two groups

Before treatment, the GMT was (1.85±0.35) cm in the control group and (1.86±0.30) cm in the observation group. A reduction in GMT was identified in both cohorts at 2, 4, 12, and 24 weeks after treatment (P<0.05), with even lower GMT in the observation group at the 2nd, 4th and 12th weeks after injection (P<0.05), as shown in **Table 4**.

Adverse reactions in the two groups

In the control group, 2 patients suffered from weakness/cramps, 2 experienced edema, and 2 developed muscle tenderness in both legs, with a total incidence of 24.9%. In the observation group, only 1 case of weakness/cramps was observed, with an overall incidence of 4.2%. The above data revealed a notably lower incidence of adverse reactions in the observation group than that in the control group, with statistical significance (P<0.05), as shown in **Table 5**.

Satisfaction in the two groups

In the control group, 19 cases were very satisfied, 1 case was basically satisfied, and 4 cases were dissatisfied, with a total satisfaction rate of 83.4%. In the observation group, the number of patients who rated the treatment as very satisfied, satisfied, and dissatisfied was 23, 1, and 0, respectively, with a total satisfaction rate of 100%. These data revealed a statistically higher overall satisfaction rate in the observation group compared to the control group (P<0.05), as shown in **Table 6**.

Table 5. Comparison of adverse reactions between the two groups

Groups	Weakness/cramps (n)	Edema (n)	Muscle tenderness in both legs (n)	Total incidence
Control group (n=24)	2 (8.3)	2 (8.3)	2 (8.3)	6 (24.9)
Observation group (n=24)	1 (4.2)	0 (0)	0 (0)	1 (4.2)
χ^2				4.1811
P				0.0409

Table 6. Comparison of satisfaction between the two groups

Groups	Very satisfied	Basically satisfied	Dissatisfied	Overall satisfaction
Control group (n=24)	19 (79.2)	1 (4.2)	4 (16.6)	20 (83.4)
Observation group (n=24)	23 (95.8)	1 (4.2)	0	24 (100.0)
χ^2				4.3641
P				0.0367

Discussion

In recent years, an increasing number of women have sought beauty treatments to contour chunky, unsightly calves. Subcutaneous adipose tissue accumulation and calf muscle hypertrophy are the main factors leading to poor calf appearance, the former of which can be addressed with liposuction. For the latter, the gastrocnemius determines the calf contour curve and affects the fitness and slender of the calf. Plasticity and volume reduction of gastrocnemius are the ways to shape a good calf curve [18], in which partial muscle resection and neurotomy of the calf can be adopted. However, these invasive measures lead to long recovery time, predispose patients to various complications and scarring, and affect the motor function of the calf. Therefore, non-surgical calf contouring methods have been continuously pursued clinically in recent years. Of these, BTX-A is a neurotoxin drug and can relax and atrophy gastrocnemius muscle when it is injected, thus improving calf appearance without affecting activities such as standing and walking. However, its disadvantage is that it does not work well in the long term [19]. According to relevant research, the effect of botulinum toxin is almost insignificant 6 months after the injection, so doctors usually recommend repeated injections to maintain the contour of the leg [4]. Therefore, studies are needed to confirm whether post-injection assisted rehabilitation can play a role in maintaining the efficacy of BTX-A injections in the long term.

In this study, we compared the efficacy of BTX-A injection in subjects who received routine care versus those received auxiliary rehabilitation training after injection. It was found that BTX-A injections effectively reduced the CC and GMT and achieved satisfactory calf contouring effects. Comparatively, subjects who received post-injection auxiliary rehabilitation training developed significantly fewer adverse reactions and had markedly higher satisfaction than those receiving routine care. Generally, in clinical practice, the improvement of calf shape can be observed 2 weeks after the injection, and the best results can be achieved in about 2 months. The CC can usually be reduced by 0.7-2.5 cm and maintained for 6-8 months, and recovered at about 6 months. Then, the injection can be repeated 6-12 months later, for 3-4 times in a row, depending on the change of calf shape. Despite the obvious benefits of BTX-A, frequent injections of large doses of BTX-A (controlled under 300 units of total injection for calf contouring and no more than 400 units of mixture injected at other sites at the same time) can increase the risk of complications and lead to the production of antibodies in the body. Research has suggested that it is better to set several injection points and inject a target muscle evenly. Therefore, in addition to toxin diffusion, injection efficiency and injection speed are also crucial factors in BTX-A injection technology [20]. In this study, there are also patients who did not respond well, despite the use of BTX-A to correct the gastrocnemius swelling during calf contouring. Anatomically speaking, the gastrocnemius has lateral and

medial muscle heads in the hind limbs. The drug diffusion is known to vary at different sites. Compensatory hypertrophy of synergistic muscle groups that are not affected by drugs may lead to poor effects under various actions. The overall multi-point injection method ensures that the amount of muscle injection is uniform and consistent, which helps the drug spread rapidly while avoiding the discomfort caused by large doses of injection at once, helping to reduce patient fear and resistance. The method of focusing on the lateral edge can avoid deep neurovascular damage and prevent the function and mobility of the muscles in the middle part from being affected. This approach ensures post-injection comfort while reducing the contraction force of the lateral muscles, thus contributing to better plastic effects.

In addition, it is generally believed that it is necessary to reduce muscle activity as much as possible after BTX-A injections, such as avoiding massage of the injection site and to be aware of drug incompatibility. From a long-term effect point of view based on our findings, beauty seekers should be properly coached to do low-intensity aerobic exercise, stretch their calves regularly, and do some less explosive exercise. Moreover, dorsal stretching training, as well as post-treatment aerial walking and roller stretching, can be carried out, with the aim of burning off superficial fat and shaping lines. According to the results of this study, reasonable rehabilitation training can reduce the incidence of adverse reactions and improve the satisfaction of the patients. Still, this study has some limitations. The small sample size of this study and the short follow-up period make it impossible to observe the long-term efficacy of BTX-A injections combined with assisted rehabilitation training. Also, further studies should be conducted on the selection of injection dose and injection site of BTX-A. Therefore, prospective large sample size trials are needed in the future.

To sum up, BTX-A injections have high application value in calf plasticity, and the combination of injections and reasonable auxiliary rehabilitation training can effectively reduce the incidence of adverse reactions and improve the satisfaction of patients. In addition, BTX-A should be injected based on the actual condition of the patient's calf in order to reasonably formulate the injection plan that can plasticize the calf while ensuring safety.

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Disclosure of conflict of interest

None.

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