Proposal of a Modified Comprehensive Technique to Avoid Local Scarring and Adhesion Formation for Isolated Gastrocnemius Recession: a Comparison Study.

Jiafa Zheng

Second People's Hospital of Dalian <https://orcid.org/0000-0002-1625-5927>

Xiufeng Song

The Second People's Hospital of Dalian

Min Guan

Dalian Second People's Hospital

Zhiming Qi (✉ 1438190369@qq.com)

Dalian Second People's Hospital

Research

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Abstract

Background

Poor cosmesis is one of the complications following surgical gastrocnemius recession by Strayer procedure. Our present study reported a modified comprehensive technique avoiding skin adhesion in releasing gastrocnemius contracture. A comparison cohort was conducted with inclusion cases via comprehensive modified technique and conventional Strayer procedure.

Methods

From July 2017 to December 2019, 72 consecutive patients (84 feet) were retrospectively reviewed with 38 cases (42 feet) treated utilizing conventional Strayer procedure and 34 cases (42 feet) treated by modified comprehensive technique. All patients were followed up for minimum 12 months (mean 13.6, range 12 to 18 months). The ankle dorsiflexion range of motion and medical complications (scar adhesion) of above patients were recorded and evaluated.

Results

The mean ankle dorsiflexion significantly improved from $14.5^{\circ} \pm 2.5^{\circ}$ degrees preoperatively to $-18.7^{\circ} \pm 3.2^{\circ}$ degrees in modified procedure group postoperatively ($P < 0.05$), while dorsiflexion improved from $15.2^{\circ} \pm 3.0^{\circ}$ to $-19.1^{\circ} \pm 3.9^{\circ}$ in conventional Strayer procedure group. 1 of 42 (2.4%) in modified procedure group developed scar adhesion while 12 of 42 (28.6%) in conventional Strayer procedure group, which showed a statistically significant difference in postoperative complication (scar adhesion) rate between two groups ($P < 0.05$).

Conclusions

Gastrocnemius recession with modified comprehensive technique can completely release the gastrocnemius aponeurosis and achieve satisfactory recovery of ankle dorsiflexion angle, especially effectively avoid postoperative local scar adhesion with a superior cosmetic appearance.

Level of Clinical Evidence: 3

Background

The gastrocnemius contracture is often encountered in patients with foot and ankle pathology, and a higher incidence was identified especially for noninvasive etiology including hallux valgus, flat foot and so on (1–6). Three procedures of surgical gastrocnemius recession are commonly performed, including Vulpus procedure, Strayer procedure and Baumann procedure (7–16). Strayer procedure, which releases proximal medial gastrocnemius, is most popular method in the past few years, whereas postoperative complications such as poor cosmesis are often unavoidable, with a rather high complication rates of sural nerve injury, hematoma formation, strength deficits and contracture recurrence (17–26).

Due to the tethering of the wound skin and underlying fascia, postoperative problematic scarring and adhesion formation with hypertrophic or keloid scar could cause cosmetically unsatisfactory calf and evidently affect the surgical satisfaction of gastrocnemius recession, especially among young females (16).

To the best of our knowledge, no literatures has been reported to address the cosmetic and satisfactory concern. Our present study initially proposed a novel modified comprehensive technique, by utilizing preoperative color Doppler ultrasound to accurately mark the modified incision, operating gastrocnemius recession during plantarflexion and then dorsiflexion as to address the cosmetic complications of Strayer procedure. The outcomes of current comprehensive technique were measured and analyzed, and compared with that of a conventional Strayer procedure group.

Methods

From July 2017 to December 2019, 72 patients (84 feet) from our medical center were consecutively included in this retrospective cohort study, including 4 males (4 feet) and 68 females (80 feet), of which 56 patients (68 feet) were managed with gastrocnemius recession procedure for hallux valgus, 13 patients (13 feet) for flatfoot and 3 patients (3 feet) for metatarsophalangeal joint replacement. And 38 cases(42feet)were managed with conventional Strayer procedure while 34 cases42feetwere treated with modified comprehensive technique (Table 1). The most commonly used criterion to indicate an isolated gastrocnemius contracture is that $> 10^\circ$ of dorsiflexion with the knee extended, which improves past neutral with knee flexion (8). The angles of plantarflexion and dorsiflexion are indicated by positive and negative values, respectively.

Table 1
Patient information of the two Groups

	Modified group	Conventional group
Patients	34 (42 feet)	38 (42 feet)
Male/Female	2/32	2/36
Hallux valgus	26 (34 feet)	30 (34 feet)
Flatfoot	7 (7 feet)	6 (6 feet)
Replacement of metatarsophalangeal joint	1 (1 feet)	2 (2 feet)

Conventional Strayer procedure

The skin incision for the Strayer procedure is made at the level of the musculotendinous junction of the gastrocnemius in line with the posterior border of the medial malleolus. The level of the incision has been described as 2cm distal to the gastrocnemius indentation.(16) The gastrocnemius and soleus fascial

layers are bluntly dissected down and the gastrocnemius fascia is transected one to two fingerbreadths distal to the musculotendinous junction without disruption of the soleus.

Procedures of modified comprehensive technique

Preoperatively, at plantarflexion position, color Doppler ultrasound was utilized to detect the musculotendinous junction of the well-placed affected foot, and the musculotendinous junction was marked on the skin. The center of the modified incision should be located approximately 3cm to the vertical line of the medial border of the tibia.

Intraoperatively, place the affected foot at extreme plantarflexion, a 3-cm vertical incision was made through skin at the previously marked modified incision. The subcutaneous tissue and superficial fascia were bluntly dissected down. The gastrocnemius musculotendinous junction was cut off along the borders of medial and lateral heads of gastrocnemius, respectively. Then the ankle was forcefully held in dorsiflexion prolonging the gastrocnemius musculotendinous junction to reach a satisfying dorsiflexion angle. Thus, the avulsion was located distally to the skin and soft tissue incision to effectively avoid direct contact of avulsion and incision to reduce adhesion formation. Then fat and subcutaneous tissue were sutured by absorbable thread conventionally.

Postoperatively, the affected leg was immobilized in a plaster while the ankle was kept at neutral dorsiflexion for 2–3 weeks. The patients were encouraged to perform Achilles tendon and gastrocnemius-stretching exercises and ankle motion exercises during intermittent removal of plaster to further prevent scarring and adhesion formation.

The principle of modified comprehensive technique to prevent postoperative scar adhesion

The color Doppler ultrasound was utilized to detect the musculotendinous junction and the musculotendinous junction was marked on the skin at extremely plantarflexion position (Fig. 1, location A), then the musculotendinous junction was marked again during extremely dorsiflexion (Fig. 2, location B).

According to the distance between A and B, posterior medial edge of the tibia can be palpated, and the longitudinal or small arc incision was performed at the vertical line about 3cm from the posterior medial edge. The incision can be extended regrading the intersection of incision and line A as the center but avoiding any overlapping of incision and line B. With ankle plantarflexion, the gastrocnemius musculotendinous junction was exposed and cut off sharply. With extreme dorsiflexion, the lower edge of the gastrocnemius muscle slid to B (Fig. 2), and the musculotendinous junction was prolonged and extended to the distal end (C in Fig. 2). Thus, there was no direct contact between the incision D and extension area C, effectively preventing postoperative scar adhesions. Noteworthily, line E (Fig. 1) is the position of sural nerve, and it should be protected during the surgery thus exposure was not recommended.

The diagnostic criteria of scarring and adhesion formation: skin and soft tissue on operative incision scar moved with dorsiflexion and plantarflexion of the ankle joint, affecting the cosmetic appearance or patients complained about local stiffness and discomfort.

Statistical analysis

The Statistical Package for the Social Sciences (version 19.0; SPSS, Inc, an IBM Company, Chicago, IL) was used for the statistical analysis of data. The maximum passive dorsiflexion angles of the ankle joint preoperatively and postoperatively within the group and between the groups were expressed in mean $\pm$ standard deviation ($\bar{x} \pm s$) and analyzed by the paired t test. Postoperative complication (scarring and adhesion formation) between the groups was compared using χ^2 test. A *P* value of less than 0.05 was defined to be statistically significant.

Results

The mean follow-up was 13.6 months (12 to 18 months). All of them had obvious improvement in the maximum passive dorsiflexion angle of the ankle joint with knee extension. The mean ankle dorsiflexion significantly improved from $14.5^\circ \pm 2.5^\circ$ degrees preoperatively to $-18.7^\circ \pm 3.2^\circ$ degrees in comprehensive modified procedure group (Modified group) postoperatively ($P < 0.05$), while dorsiflexion improved from $15.2^\circ \pm 3.0^\circ$ to $-19.1^\circ \pm 3.9^\circ$ in conventional Strayer procedure group (Conventional group) ($P < 0.05$) (Table 2).

Table 2
Comparison of dorsiflexion angle of ankle joint with knee extension

	Modified group	Conventional group	T-Value	P-Value
Preoperative angle	$14.5^\circ \pm 2.5^\circ$ #	$15.2^\circ \pm 3.0^\circ$ *	1.138	0.262
Postoperative angle	$-18.7^\circ \pm 3.2^\circ$ #	$-19.1^\circ \pm 3.9^\circ$ *	0.411	0.683
#T-Value 63.93 P-Value 0.000 * T-Value 45.88 P-Value 0.000				

One foot of 42 (2.4%) in modified procedure group developed scar adhesion while 12 of 42 (28.6%) in conventional Strayer procedure group, which showed a statistically significant difference in postoperative complication (scar adhesion) rate between two groups ($P < 0.05$). (Table 3)

Table 3
Comparison of postoperative local scarring and adhesion formation in both group

	Scar adhesion (foot)	Non-adhesion (foot)	Total (foot)	Adhesion rate(%)
Modified group (foot)	1	41	42	2.4
Conventional group (foot)	12	30	42	28.6
Total (foot)	13	71	84	15.5
P-Value 0.003				

Discussion

Currently, the commonly used procedure for releasing gastrocnemius aponeurosis was that the longitudinal incision on posterolateral lower leg was performed in the midpoint of the fibular head to the tip of the lateral malleolus (7–16). One of the common postoperative complications was local scar adhesion, in which skin and soft tissue of the incision scar moved during dorsiflexion and plantarflexion of the ankle joint, affecting the appearance and some patients complained about local stiffness and discomfort (16).

The possible mechanisms of the adhesion formations are as follows: the direct contact of incision tissue and the avulsion of the releasing gastrocnemius aponeurosis; the immobilization for a long period of time with ankle joint in neutral position by plaster postoperatively; the lack of related active and passive exercise of ankle joint for functional rehabilitation.(17) The first point was considered to be the main cause for it resulted in local scar hyperplasia and adhesion in the healing process. Therefore, we designed a modified incision monitored by color Doppler ultrasonography, avoiding the superficial incision of skin soft tissue overlapped with the deep releasing avulsion of gastrocnemius aponeurosis. Utilizing the modified technique, preferable results were achieved except for limited local scar adhesion rate of 2.4%, possibly due to the overlap of the longer and lower incision with the avulsion of gastrocnemius release. Meanwhile one patient showed the symptom of gastrocnemius injury in both experimental and control group, which possibly due to the limited incision and excessive traction, and the patients recovered from the deficit within one month with neurotrophic medication. Generally, the ankle dorsiflexion angles (with knee extension) were restored to $-18.7^{\circ} \pm 3.2^{\circ}$ from the preoperative $14.5^{\circ} \pm 2.5^{\circ}$ ($P < 0.01$), which was consistent with the previous literature²⁰ on the lengthening of gastrocnemius aponeurosis and improvement of ankle dorsiflexion angle. Thus, the present technique was proved to be reliable and effective. It is noteworthy that the novel modified comprehensive technique can effectively prevent the postoperative scar adhesion as well as lengthen the gastrocnemius muscle.

Intraoperative patient posture

All the patients in our present study were suffering from foot pathology with various etiologies, and most of them were positioned supinely during the operation. Whereas the prone position was recommended for a clear exposure and convenient operation for surgical gastrocnemius recession. And the change of the position during the operation resulted in additional steps and prolonged intraoperative time. To the best of our knowledge, supine position with the operating table inclining to the affected side for about 30 degrees is better for operation. Meanwhile, extreme ankle plantarflexion and slight knee flexion is recommended to be maintained by assistant for better surgical exposure.

Incision technique

According to the mark of the musculotendinous junction by ultrasonography preoperatively, the intraoperative incision was made as proximal as possible, and then was extended to distal junction area appropriately after the blunt exposure of gastrocnemius layer by layer to ensure that the distal end of the superficial skin incision was slightly proximal to the junction area (**as indicated by the arrow in Fig. 3**). If the incision was extended too far, there will increase the risk of the contact of the skin incision and the release area of gastrocnemius aponeurosis. In general, 3cm of vertical straight incision was enough; while for patients with high BMI, the incision could be extended to the proximal end, or a small arc incision can be made with vertex orientating the lateral side. After completely transection of gastrocnemius musculotendinous junction, the ankle joint was placed in extremely dorsiflexion to mobilize the avulsion of the junction. The superficial surface of the avulsion and the distance between the proximal end of loose part and the skin incision can be seen through the surgical field when the recession was completed (**as indicated by the arrow in Fig. 4**). Intraoperatively, the gastrocnemius fascia was intact within the incision and the muscle was not exposed. Thus, limited postoperative adhesion can be formed with the undamaged fascia and fat.

Conclusions

our present study introduced a novel modified comprehensive technique for releasing non-convulsive contracture of gastrocnemius muscle aponeurosis and the comparisons of surgical efficiency and complications were made between conventional Strayer procedure and modified technique, demonstrating the advantages of modified technique, especially for avoiding local scar adhesion. This present technique is worthy of spreading in foot and ankle surgery.

Declarations

Ethics approval and consent to participate

This study was conducted with approval from the Ethics Committee of Dalian Second People's Hospital and was performed in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants. For participants below 18 years, informed consents were obtained from legal guardian.

Consent for publication

We have obtained consent to publish from the participants.

Availability of data and materials

The patients' data were collected in the Dalian Second People's Hospital. The datasets analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests

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Authors' contributions

All authors have read and approved the final manuscript. JZ was involved in the study design, data collection, drafting and revising of the manuscript. JZ, XS and MG were involved in the data collection. JZ and XS were involved in the analysis and interpretation of data. MG was involved in the study design, data collection, analysis and interpretation of the data. ZQ was involved in the study design, drafting and revising of the manuscript and has given final approval.

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Figures

Figure 1

Preoperatively, color doppler ultrasound was utilized to detected the musculotendinous junction, and morphological and anatomical structures were marked on the skin: (A) The mark of gastrocnemius musculotendinous junction when ankle joint in extremely plantarflexion; (B) the mark of gastrocnemius musculotendinous junction when ankle joint in extremely dorsiflexion; (C) the mark of the junction avulsion area; (D) the mark of the surgical incision; (E) the mark of the sural nerve.

Figure 2

When ankle joint in extremely dorsiflexion: (B) the mark of gastrocnemius musculotendinous junction; (C) the white line showed the fallen deep avulsion of the gastrocnemius musculotendinous junction.

Figure 3

Intraoperative image of the Gastrocnemius Recession. The distance between distal end of the skin incision and the gastrocnemius musculotendinous junction. The intraoperative incision was made as proximal as possible, and then was extended to distal junction area appropriately after the blunt exposure of gastrocnemius layer by layer to ensure that the distal end of the superficial skin incision was slightly proximal to the junction area (red line).

Figure 4

In plantarflexion, the incision of skin soft tissue and loose part. The enlarged image showed the gastrocnemius musculotendinous junction (red arrow). The superficial surface of the avulsion and the distance between the proximal end of loose part and the skin incision can be seen through the surgical field when the recession was completed.