

The discovery and clinical significance of the “Twin Open Skylight and Summon Effects” of the Ilizarov tibial transverse transport technique

W. Chen¹, Q. Hua^{1,2}, J. Zhao^{1,2}, L. Qu³

¹Research Centre for Regenerative Medicine, International Joint Laboratory on Regeneration of Bone and Soft Tissues, Guangxi Medical University, Nanning, China

²The First Affiliated Hospital of Guangxi Medical University, Nanning, China

³731st Hospital of Chinese Aerospace Science and Industry Corporation, Beijing, China

Ilizarov's tibial transverse transport (TTT) technique can promote vascular regeneration. It has been used in the treatment of a variety of lower limb ischemic diseases, such as thromboangiitis obliterans, diabetic foot ulcers, etc. Recently, several novel therapeutic effects have been discovered based on TTT treatment. For instance, in the treatment of thromboangiitis obliterans, an “Open Skylight Effect” was well defined in which the symptom of resting pain disappeared following tibial cortex osteotomy (Long Qu, 2001). During the treatment of bilateral diabetic foot gangrene, patients that received TTT treatment on the one side of the lower limb were observed to have a simultaneous healing of ulcers on both sides, which was termed as the “Summon Effect” (Qikai Hua, 2017). In 2019, we characterized the above discoveries as the “Twin Open Skylight and Summon Effects”. These findings will inspire more potential clinical applications of TTT technique.

Keywords: tibial transverse transport, twin open skylight and summon effects, revascularization, ectopic regeneration

Since the middle of the 20th century, the Ilizarov's techniques and principles have produced a “Butterfly Effect” in the field of orthopaedics, which has greatly promoted the development of clinical regenerative medicine [1].

After half a century of practice, the understanding of Ilizarov's techniques has evolved from “Distraction Osteogenesis (DO)” to “Distraction Histogenesis (DH)” and “Transformation Histogenesis (TH)” (“Harbin Phenomenon”) which describes the transformation and regeneration capacities of both normal and abnormal tissues. The above principles came from the Ilizarov's notion of bone lengthening and longitudinal bone transport techniques. The practice of the Ilizarov tibial transverse transport technique has also revealed many new applications and discoveries.

The Ilizarov Tibial Transverse Transport (TTT) technique was first designed for thickening of lower limbs [1]. Nowadays, due to its revascularization effect, it has also been used to treat various lower limb ischemic diseases, such as thromboangiitis obliterans (TAO), diabetic foot ulcers, etc. Clinical evidence shows that this technique can effectively promote angiogenesis and save limbs from amputation.

The TTT technique was firstly introduced to China by Dr. Long Qu in 2001 [2]. He designed the surgical instruments and further applied the TTT technique to

treat thromboangiitis obliterans and other lower limb ischemic diseases [2, 3]. He found that the symptoms of resting pain, coldness and numbness were alleviated within 24 hours following a tibial cortex osteotomy. The osteotomy resembles the skylight in the tibia, for which he named it the “Open Skylight Effect”. In 2017, Dr. Hua Qikai summarized and analyzed 200 cases of diabetic foot gangrene treated with TTT technique. He found that 10 % patients had diabetic foot ulcers in both lower limbs, but one side was too severe and not suitable to receive an operation. The TTT technique was performed on the side with less gangrene. Unexpectedly, the condition of the limb with a more severe lesion also improved significantly. This magical heterotopic healing phenomenon was called the “Summon Effect”. By 2019, Dr. Hua Qikai has used the TTT technique to treat more than 500 cases of diabetic foot gangrene [4, 5]. The two miraculous phenomena have been continuously verified in the treatment of ischemic diseases for its outstanding effects on local blood supply and subsequent tissue repair [6].

Based on these findings, we discovered that these two phenomena are complementary and mutually supportive. In 2019, Dr. Weiwei Chen termed them “Twin Open Skylight and Summon Effects” [6]. The twin effect generated by TTT technique plays a vital role in symptomatic improvement and ectopic repair (Table 1).

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Table 1

The “Twin Open Skylight and Summon Effects”

	Open Skylight Effect	Summon Effect
Clinical evidence	Symptoms (pain, coldness, numbness, etc.) are improved rapidly after tibia osteotomy.	Local angiogenesis with ectopic angiogenesis occurs during the procedure
Time of effect	Fast (1 day after the tibia osteotomy)	Slow (about 25 days after the operation)
Mechanism conjecture	Rapid changes in intraosseous pressure, improvement of regional nerve ischemia, and reconstruction of the microvascular network in the bone marrow, all help to relieve the symptoms	Spontaneous vascular remodeling at the site of ischemia, the synergistic effects of systemic regeneration factors, and the restoration of the nerve conduction in the bone marrow, all help to produce ectopic regeneration

The “Twin Open Skylight and Summon Effects” is an extension of Ilizarov's biological principles and was proposed to strengthen the ability of “Ectopic Transformation and Regeneration”, more specifically, the transformation and regeneration capacities of abnormal tissues. The TTT technique may not only improve the local blood supply of the diseased tissues but also encourage the

reconstruction of blood vessels throughout the body, and even the recovery of nerve function. The “twin effect” may serve as a prelude to the exploration of this technique, which can advance our understanding of the mechanisms of the TTT technique. Thus, we expect to see some more potential applications of the TTT technique developed to overcome intractable diseases.

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Information about the authors:

1. Weiwei Chen,
Research Centre for Regenerative Medicine, International Joint Laboratory on Regeneration of Bone and Soft Tissues, Guangxi Medical University, Nanning, Guangxi, China,
Email: chenww08@126.com
2. Qikai Hua,
Research Centre for Regenerative Medicine, International Joint Laboratory on Regeneration of Bone and Soft Tissues, Guangxi Medical University, Nanning, China,
The First Affiliated Hospital of Guangxi Medical University, Nanning, China,
Email: hqk100@yeah.net
3. Jinmin Zhao,
Research Centre for Regenerative Medicine, International Joint Laboratory on Regeneration of Bone and Soft Tissues, Guangxi Medical University, Nanning, China,
The First Affiliated Hospital of Guangxi Medical University, Nanning, China,
Email: zhaojinmin@126.com
4. Long Qu,
731st Hospital of Chinese Aerospace Science and Industry Corporation, Beijing, China,
Email: 50273414@qq.com