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Distinct Neuroanatomical Structures of Acupoints Kidney 1 to Kidney 8: A Cadaveric Study

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ABSTRACT

Objective: The *Systematic Classic/Zhen Jiu Jia Yi Jing* (*ZJJYJ*, 鍼灸甲乙經) is considered to be the first complete acupuncture manual to detail the location and meridian assignations of 349 acupuncture points. Despite numerous transcriptions and editing changes, many traditional acupuncturists adhere to the classics and rarely question their validity. However, ushering the use of acupuncture into the modern era requires examining acupuncture point locations objectively by comparing contemporary anatomical knowledge with classical texts. The aim of this research was to examine distinct neuroanatomical targets associated with acupuncture points to: (1) standardize the precise neuroanatomical target of each acupuncture point; and (2) crossreference neuroanatomical targets with classical point locations. This was done to demonstrate ancient authors' intentions when describing acupuncture points as coordinates used to stimulate the peripheral nervous system.

Materials and Methods: The unique neuroanatomical targets associated with acupuncture points on the Foot *Shao Yin* Kidney meridian were defined. Specifically, KI 1 through KI 8 were examined by comparing classical point locations from the *ZJJYJ* with modern standardized textbook locations from Chinese Acupuncture and Moxibustion, current anatomical literature, the current authors' cadaver dissection research, and electrostimulation of acupuncture points in healthy volunteers.

Results: KI 1–KI 8 correlated with motor entry points as well as with nerve branches and vessels derived from the posterior tibial neurovascular bundle.

Conclusions: This research demonstrated a procedure to verify and standardize the distinct neuroanatomical structures of acupuncture points. Standardization of neuroanatomical targets of acupuncture points will enable researchers and clinicians to obtain reproducible results in clinical treatments and research protocols.

Keywords: electroacupuncture, Traditional Chinese Medicine, meridians, Kidney meridian, neuroanatomy

INTRODUCTION

For thousands of years, the art and science of acupuncture has relied on the descriptions of meridians to locate acupuncture points and describe their functions. Medical classics such as the *Plain Question* (*Su Wen*, *SW*, 素問)[1] and *Spiritual Pivot* (*Ling Shu*, *LS*, 灵枢经)[2] theorized that meridians were conduits that transport Qi (氣), or energy, which is widely believed to have no direct correlation with any known anatomical structures. Popular opinion suggests that, due to conservative Confucian values and ancestral worship, the ancient Chinese did not dissect their

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dead. Rather, meridians and acupuncture-point locations were inferred through the use of palpation, meditation, and exercise techniques used on living patients. However, a growing body of scientific literature suggests that meridians and acupuncture points were not discovered through subjective inferences but were based instead on observations of cadaveric dissections, and that, therefore, acupuncture was firmly based on the science of anatomy.[2,3]

Pioneering research to investigate the anatomical significance of acupoints systematically began in 1959 at the Shanghai First Medical College (now the Shanghai Medical College of Fudan University).[4] Researchers demonstrated that 323 of 324 dissected acupoints were associated with peripheral nerves; 93.8% (304/324 acupoints) were associated with superficial cutaneous nerves; and 52.5% (170/324 acupoints) were associated with deep nerve trunks.[5] Similarly, researchers at the Shanghai Traditional Chinese Medicine (TCM) College (now Shanghai TCM University) found that, among 309 dissected acupoints, needles touched the trunks of nerves directly in 152 acupoints (49.2%). The nerve trunks were within 0.5 cm of the remaining 157 acupoints (50.8%) acupoints.[5] These studies provided compelling insight into what ancient acupuncturists were observing and documenting when they chose to record—in what would eventually become seminal medical canons—the precise location of acupuncture points as unique peripheral nerve-stimulation sites.

The *Systematic Classic/Zhen Jiu Jia Yi Jing* (*ZJJYJ*, 鍼灸甲乙經), written in 259 AD, is considered to be the first complete acupuncture manual to detail the location and meridian assignations of 349 acupuncture points.[6] Despite numerous transcriptions and editing changes more than 1700 years ago, many traditional acupuncturists adhere to the classics and rarely question their validity in modern medicine. It is the authors' joint opinion that, to usher the use of acupuncture into the modern era truly, acupuncture-point locations need to be examined objectively by comparing contemporary anatomical knowledge with classical textual research.

This would achieve two goals. The first goal would be standardization of the precise neuroanatomical target of each acupuncture point. If point stimulation is solely based on a two-dimensional surface coordinate without defining its three-dimensional neuroanatomical target beneath the skin, different researchers stimulating the same acupuncture point could, in fact, be stimulating different structures. This makes interpretation of outcomes from different studies impossible. Standardizing the precise target of each acupuncture point would allow for reproducibility of results in research and clinical settings. The second goal would be, using classical point locations to crossreference distinct neuroanatomical targets, to demonstrate to traditional acupuncturists the ancient sages' original intentions in using precise locations to stimulate the peripheral nervous system. Overall, this would, it is hoped, inspire interest in studying neuroanatomy so that interprofessional collaboration and communication based on the same medical language would become possible.

With these goals in mind, this article reports on the examination of distinct neuroanatomical targets associated with acupuncture points on the Foot *Shao* Yin Kidney meridian, specifically Kidney1 (KI 1) through Kidney 8 (KI 8).

MATERIALS AND METHODS

The distinct neuroanatomical target associated with each acupuncture point, KI 1 through KI 8, was examined by consulting Chinese Acupuncture and Moxibustion[7] and *ZJJYJ* texts. This information was compared with modern anatomical resources/research articles, the current authors' own cadaveric dissections, and electrostimulation of acupoints in healthy volunteers. When the Chinese Acupuncture and Moxibustion[7] and *ZJJYJ* texts had different locations for these points, they were verified with peer-reviewed articles, cadaveric dissections, and monopolar electrostimulation of the acupoints on healthy volunteers.

The 349 acupoints listed in the *ZJJYJ* were transliterated into English as the English version is a translation itself. Transliteration reduces misinterpretation of anatomical landmarks that are required for precise locations. This article includes the transliterations of KI 1 through KI 8 (Table 1).

Anatomical Dissection

The dissection specimen was an 88-year-old female body acquired for anatomical education via the Human Body Donation Program at Queen's University, in Kingston, Ontario, Canada. The specimen was fixed with vascular perfusion, using a mixture of liquid phenol, 95% ethanol, glycerin, and water. The dissection occurred at the Anatomy Learning Centre in the Queen's University as a part of its Complementary and Alternative Medicine—Human Dissection Experience program.

Electrostimulation of Acupoints

The neuroanatomical targets of KI 1 through KI 8 were verified by electroacupuncture. Stimulation of KI 1 through KI 8 was performed with a Pointer Plus device (a 10-Hz monopolar electrostimulation device; Mayfair Medical Supplies Ltd., Hong Kong). The responses, which were cutaneous paresthesia and/or muscle recruitment, were then compared to the actions of the examined cutaneous nerves, muscles, and motor nerves.

RESULTS

The results were as follows:

KI 1,Gushing Spring—KI-1 coincided with the location of the deep branch of the lateral plantar nerve (Fig. 1).

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Table 1. Point Location Comparisons Between Classical Texts & Reinterpreted Anatomy for Kidney 1 – Kidney 8 & M-LE 5

Acupoint	*ZJJYJ & transliteration*	*Chinese Acupuncture & Moxibustion*[7] *modern TCM location*	*Reinterpreted anatomy*	*Innervated muscle groups*
KI 1 涌泉 *Yǒng Quán* Gushing Spring	湧泉者，水也。一名地衝，在足心陷者中，屈足卷指宛宛中，足少陰脈之所出也，為井。 刺入三分，留三呼，灸三壯 In a depression in the center of the foot, in the middle of the curvature when foot is bent & toes are curled	On the sole, in the depression where the foot is in plantar flexion, approximately at the junction of the anterior 1/3 & posterior 2/3 of the line connecting the base of the 2nd & 3rd toes & heel	Deep branch of lateral plantar nerve & deep plantar arch of lateral plantar artery	Flexor digiti minimi brevis, the 4th dorsal & 4th plantar interossei muscles, adductor hallucis muscle, lateral lumbrical, abductor hallucis brevis, flexor hallucis brevis, & flexor digitorum brevis
KI 2 然谷 *Rán Gǔ* Blazing Valley	然谷者，火也。一名龍淵，在足內踝前起大骨下陷者中，足少陰脈之所留也，為滎。 刺入三分，留三呼，灸三壯。刺之多見血，使人立飢欲食。 In depression below the protruding large bone (navicular bone) in front of the inner ankle (malleolus)	Anterior & inferior to the medial malleolus, in the depression on the lower border of the tuberosity of the navicular bone	Abductor hallucis motor point	Abductor halluces
KI 3 太谿 *Taì Xī* Supreme Stream	太溪者，土也。在足內踝後跟骨上動脈陷者中，足少陰脈之所注也，為俞。刺入三分，留七呼，灸三壯。 In the depression of the pulsating vessel (posterior tibial artery) behind the inner ankle bone (malleolus) above the heel bone (calcaneus)	In the depression between the tip of the medial malleolus & Achilles tendon	Trifurcation of posterior tibial nerve	Abductor hallucis, flexor digitorum brevis, flexor hallucis brevis, 1st lumbrical, quadratus plantae, flexor digiti minimi, adductor hallucis, interossei, 3 lumbricals & abductor digiti minimi
KI 4 大鐘 *Dà Zhōng* Great Bell	大鐘，在足跟後衝中，別走太陽足少陰絡，刺入二分，留七呼，灸三壯。 In the middle of the surging (posterior tibial artery) behind the heel	Posterior & inferior to the medial malleolus, in the depression anterior to the medial side of the attachment of Achilles tendon	Medial calcaneal nerve, also known as the medial calcaneal branch of the tibial nerve	Sensory skin over medial calcaneus
KI 5 水泉 *Shuǐ Quán* Water Spring	水泉，足少陰，去太谿下一寸，在足內踝下，刺入四分，灸五壯。 1 cun below KI 3, below the inner ankle bone (malleolus)	1 cun directly below KI 3 in the depression of the medial side of the tuberosity of the calcaneum	Lateral planter nerve	Quadratus plantae, flexor digiti minimi, adductor hallucis, interossei, 3 lumbricals, & abductor digiti minimi

(*continued*)

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TABLE 1. (CONTINUED)

Acupoint	*ZJJYJ & transliteration*	*Chinese Acupuncture & Moxibustion*[7] *modern TCM location*	*Reinterpreted anatomy*	*Innervated muscle groups*
KI 6 照海 *Zhào Hǎi* Shining Sea	照海，陰蹻脈所生，在足內踝下一寸，刺入四分，留六呼，灸三壯。 1 cun below the inner ankle bone (malleolus)	In the depression below the tip of the medial malleolus	Medial plantar nerve	Abductor hallucis, flexor digitorum brevis, flexor hallucis brevis and the first lumbrical
KI 7 復溜 *Fù Liū* Returning Current	複溜者，金也。一名伏白，一名昌陽，在足內踝上二寸陷者中，足少陰脈之所行也，爲經。刺入三分，留三呼，灸五壯。 In the depression 2 cun above the inner ankle bone (malleolus)	2 cun directly above KI 3, on the anterior border of Achilles tendon	Posterior tibial nerve	Same as KI 3
KI 8 交信 *Jiāo Xìn* Exchange Belief	交信，在足內踝上二寸，少陰前，太陰後，筋骨間，陰蹻之。刺入四分，留三呼，灸三壯。 2 cun above the inner ankle bone (malleolus), in front of *Shao Yin*, behind *Tai Yin*, between the sinew (Achilles tendon) & bone (tibia)	0.5 cun anterior to KI 7, 2 cun above KI 3 posterior to the medial border of the tibia	Posterior tibial artery	Not applicable
M-LE 5 *Shi Mian* Lost Sleep	Did not exist in *Systematic Classic*	In the center of the heel, on the bottom of the foot	1st branch of lateral plantar nerve, also known as Baxter's nerve or inferior calcaneal nerve	Abductor digiti minimi & sensory calcaneal periosteum, long plantar ligament, & adjacent vessels

ZJJYJ, *Zhen Jiu Jia Yi Jing* (鍼灸甲乙經), *Systematic Classic*; TCM, Traditional Chinese Medicine.

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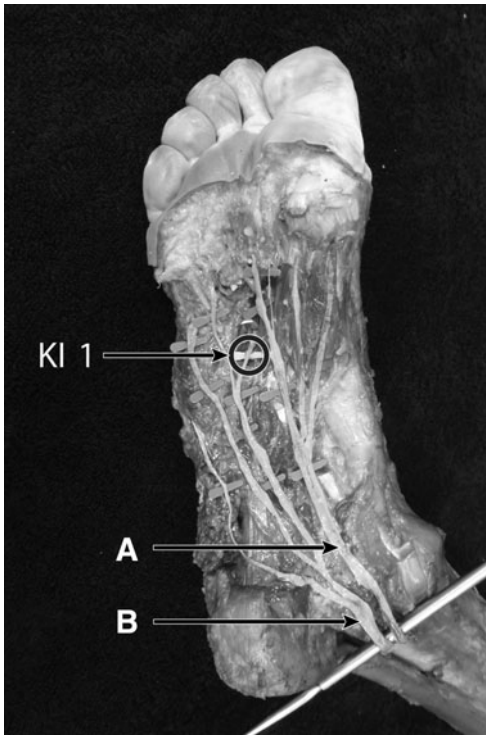

FIG. 1. KI 1 at the deep branch of lateral plantar nerve. **(A)** Medial plantar nerve. **(B)** Lateral plantar nerve.

KI 2, Blazing Valley—''In the depression below the bone'' refers to the motor point for the abductor hallucis muscle (Fig. 2). Supplementary Video 1 (Supplementary data are available online at: www.liebertonline.com/acu) demonstrates that needling of this point elicited abduction of the hallux.

KI 3, Supreme Stream—The ''pulsating vessel'' likely refers to the posterior tibial artery (Fig. 3). The posterior tibial nerve lies adjacent and posterior to the artery. This point is located at the trifurcation of the posterior tibial nerve into the medial calcaneal, medial, and lateral plantar branches. Electrostimulation of KI 3 resulted in flexion of the medial and lateral parts of the foot, attributed to the medial and lateral plantar nerves that are derived from the trifurcation of the posterior tibial nerve. See Supplementary Video 2.

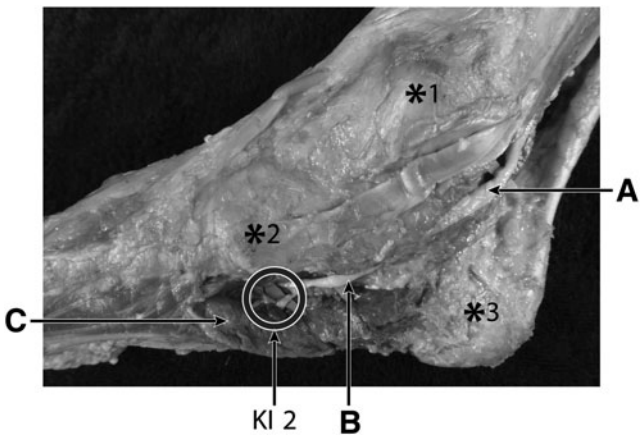

FIG. 2. KI 2 at the motor point for the abductor hallucis. **(A)** is the posterior tibial nerve; **(B)** is the medial plantar nerve; and **(C)** is the abductor hallucis muscle. *1, medial malleolus; *2, navicular bone; *3, calcaneus bone.

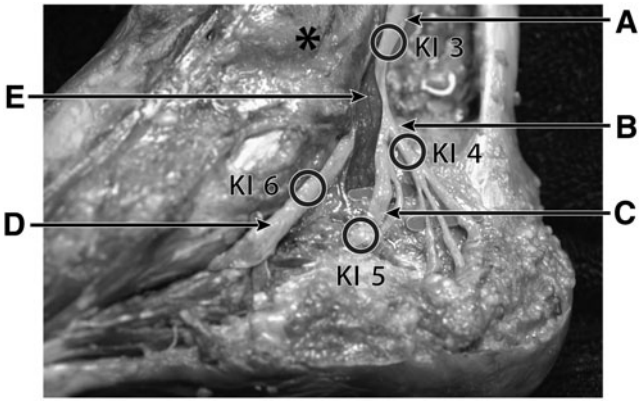

FIG. 3. Branching of the posterior tibial nerve. KI 3 as **(A)**, posterior tibial nerve; KI 4 as **(B)**, medial calcaneal branch; KI 5 as **(C)**, lateral plantar nerve; and KI 6 as **(D)**, medial plantar nerve and **(E)** posterior tibial artery.*Medial malleolus.

KI 4, Great Bell—Dissection of this area revealed the presence of the medial calcaneal branch of the tibial nerve, anterior to the Achilles tendon (Fig. 3). Needling of KI 4 resulted in paresthesia in the medial calcaneus.

KI 5, Water Spring—KI 5 lies on the lateral plantar nerve (Fig. 3). Stimulation of KI 5 along the lateral plantar nerve elicited flexion of the 5th toe via the flexor digiti quinti brevis (Supplementary Video 2) and abduction of the 5th toe via the abductor digiti minimi (Supplementary Video 3).

KI 6, Shining Sea—The medial plantar nerve is the superior branch originating from the posterior tibial nerve (Fig. 3). This branch innervates the abductor hallucis, flexor digitorum brevis, flexor hallucis brevis, and the first lumbrical. Stimulation of KI 6 resulted in flexion of the 1st toe, which coincides with the medial plantar nerve (Supplementary Videos 2 and 4). Abduction of the 1st first toe is not shown.

KI 7, Returning Current—Dissection revealed the presence of the posterior tibial nerve (Fig. 4).

KI 8, Exchange Belief—This point corresponded to the posterior tibial artery, which lies anterior to the posterior tibial nerve (Fig. 4).

Together KI 7 and KI 8 corresponded to the posterior tibial neurovascular bundle.

Please see Table 1 for a summary of acupuncture-point locations according to the classic texts and compared with modern-day neuroanatomy. Refer to Figures 1–4 and Supplementary Videos 1–4. The videos demonstrate electrostimulation of KI 2, KI 3, KI 5, and KI 6.

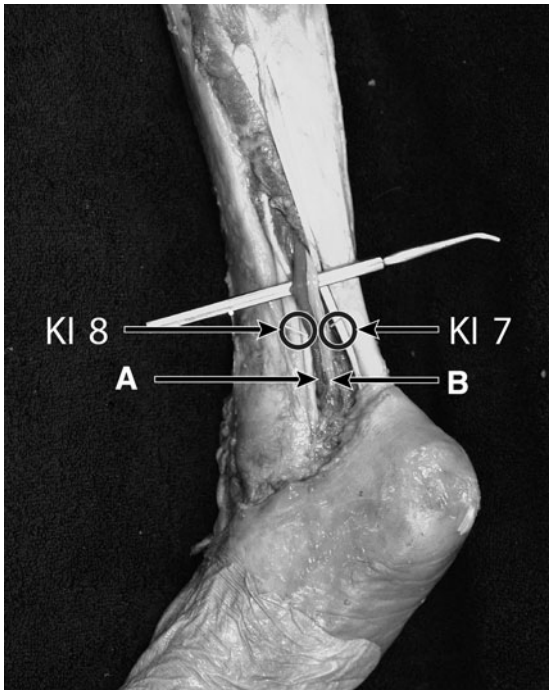

FIG. 4. Posterior tibial neurovascular bundle. **(A)** Posterior tibial artery. **(B)** Posterior tibial nerve.

DISCUSSION

KI 1 and KI 2

KI 1 coincides with the deep branch of the lateral plantar nerve (Fig 1). The deep branch of the lateral plantar nerve consists of nerve fascicles of muscular branches to the flexor digiti quinti brevis muscle, the 4th dorsal and 4th plantar interossei muscles, and the adductor hallucis muscle, as well as to the articular branches to the 5th metatarsophalangeal joint. More specifically, the deep branch of the lateral plantar nerve supplies most of the intrinsic and short muscles of the sole of the foot: lateral lumbrical; abductor hallucis brevis; flexor hallucis brevis; and flexor digitorum brevis, collectively known as the *LAFF* muscles.[8] The muscular branch to the oblique head of the adductor hallucis separates directly from the nerve fascicles constituting the deep branch of the lateral plantar nerve, whereas the muscular branch to the transverse head arises from the common branch innervating other intrinsic muscles of the foot.[8] Dissections performed by Shaw similarly showed a correlation with the Chinese Acupuncture and Moxibustion[7] locations of KI 1 and the corresponding anatomical structure of the deep plantar artery.[9]

KI 2 corresponds to the motor point of the abductor hallucis muscle, which is located more inferiorly and posteriorly to the navicular.[10,11] This muscle is an intrinsic pedal muscle that plays an important in supporting the medial longitudinal arch and controlling pronation during a static stance.[12] Specifically, abductor hallucis fatigue (stimulated by fatiguing exercises of the foot intrinsic muscles) or the administration of a tibial nerve block decreases abductor hallucis electromyographic activity and increases navicular drop.[12,13] Navicular drop can cause changes in the arch that lead to foot and plantar problems. Finally, muscle imbalance between adductor hallucis and abductor hallucis is apparent in hallucis valgus deformity.[14]

Together, KI 1 corresponds to the deep branch of the lateral plantar nerve, which also innervates the adductor hallucis muscle, while KI 2 corresponds to abductor hallucis motor point. These two acupuncture points could be implicated in the treatment of foot-related problems that affect the LAFF muscles.

KI 3 through KI 6

KI 3, KI 4, KI 5, and KI 6 all correspond to aspects of the tibial nerve. The tibial nerve provides plantar sensation to the entire foot. The tibial nerve ramification occurs posteriorly to the medial malleolus, inside the tarsal tunnel.[15] The medial calcaneal branch separates from the tibial nerve above the flexor retinaculum but is not higher than the medial malleolus (Fig. 3).

KI 4 is located on the medial calcaneal branch, which provides sensation to the heel pad. Transection of the calcaneal branch results in numbness of the heel pad.[16] Likewise, needling of KI 4 results in paresthesia in the medial calcaneus. One interesting observation to note is that KI 4 is also a *Luo*-Connecting point of the channel, which is said to encircle the heel and connect with the Bladder (BL) channel. The medial calcaneus nerve anastomoses with the lateral calcaneal nerve (sural), which satisfies this KI-to-BL connection.

Targeting this anatomy therapeutically can be useful for foot-related conditions. For example, the medial tarsal tunnel contains the following structures: flexor retinaculum (tunnel roof); talus and calcaneus (tunnel floor); tendons of tibialis posterior; flexor digitorum longus; posterior tibial artery; posterior tibial nerve; and flexor hallucis longus (tunnel content).

Medial tarsal tunnel syndrome (MTTS) is a condition that presents as pain or paresthesia along the medial plantar nerve or lateral plantar nerve (or both) sensory distribution from the ankle to the sole, with a positive Tinel's sign over the flexor retinaculum, and abductor hallucis and abductor digit quinti muscle weakness in later presentations.[17,18] Interestingly, one of the most-sensitive methods in differentially diagnosing MTTS is measurement of the sensory conduction velocity of the medial and lateral plantar nerves. This is done by stimulating the nerves at the vault of the foot.[17] It would be valuable to explore the use of KI 3-to-KI 6 acupoints to stimulate the posterior tibial nerve, its branches (e.g., the medial and lateral plantar nerves), and surrounding foot structures as a potential diagnostic and

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treatment option for MTTS. This could be used adjunctively with conservative methods—such as taping, bracing, chiropractic adjustment, massage, or fascial stripping—ultimately, to relieve irritation and decompress the nerve.

Treatment of relevant anatomy might also be applicable for Baxter's nerve-entrapment issues. Baxter's nerve entrapment can give rise to precalcaneal pain on the heel, which can also be affected in MTTS. Often, this syndrome mimics signs of plantar fasciitis and differential diagnosis in a case of plantar fasciitis is important. In Baxter's nerve entrapment, it is not the medial calcaneal branch (as it separates before the flexor retinaculum) but the first branch of the lateral plantar nerve (inferior calcaneal nerve) that is compressed.[19] KI 5, which corresponds to the lateral plantar nerve, could be indicated for Baxter's nerve entrapment. The Extra point M-LE 5; Lost Sleep or *Shi Mian* (Table 1) corresponds to the inferior calcaneal nerve (Baxter's nerve).

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KI 7 and KI 8

KI 7. In the TCM context, KI 7 is known as a strong empirical point for balancing sweating.[7] Sweating is a sudomotor response attributed to the autonomic nervous system (ANS). Anatomically, KI 7 corresponds to the tibial nerve and is located at the level of the ankle. At the level of the ankle, the tibial nerve, small arteries around the tibial nerve, and the calcaneal tendon all have sympathetic fibers.[20,21] Taken together, the sympathetic fibers in the tibial nerve likely innervate the paratendinous tissue as well as the paratendinous microvasculature of the calcaneal tendon. This could potentially explain the ability of KI 7 to reduce or stop sweating.

Another example of how the tibial nerve has been used to treat an ANS-related condition, is in overactive bladder (OAB) syndrome. The posterior tibial nerve is a mixed sensory-motor nerve with axons that pass through L-4–S-3 spinal nerve roots. These nerve roots have been known to contain peripheral nerves that are involved in sensory and motor control of the bladder and pelvic floor. These nerve roots are also targets utilized by urologists for percutaneous tibial nerve stimulation treatment. Stimulation inhibits bladder activity by stimulating large diameter somatic afferent fibers. This evokes a central inhibition of the micturition reflex pathway in the spinal cord or brain.[22] More specifically, Tai et al. were also able to isolate the effect of precise frequencies of posterior tibial nerve stimulation in a cat model: 5-Hz and 30-Hz stimulation of the posterior tibial nerve inhibited bladder activity; and short-duration stimulation induced a persistent poststimulation inhibitory effect and increased bladder capacity.[23]

Given that KI 7 corresponds to the tibial nerve, which has been used to treat syndromes associated with the ANS, such as the OAB syndrome, further investigation of the use of KI 7 and its relation to the autonomic nervous system is warranted.

KI-8. KI 8 is the *Xi*-Cleft point of the Yin Motility vessel. This point is the intersection of the Yin Motility and the Foot *Shao* Yin Kidney channel. *Xi*-Cleft points are related to Blood, while the Vessel/*Mai* in the Yin Motility all hint at a blood-vessel–related anatomy and function. For these reasons, the current authors suggest strongly that the descriptions in the classic texts are referring to the posterior tibial artery (as opposed to posterior tibial nerve), which lies anteriorly to the nerve.

CONCLUSIONS

Based on literature reviews of classical texts, anatomical literature, and the current authors' dissections and electrostimulation videos, distinct neuroanatomical targets were demonstrated for the acupuncture points KI 1 to KI 8. These anatomical targets include the tibial nerve trunk, the tibial nerve branches, and the muscles that the branches innervate, as well as the tibial artery. Identifying these targets will allow for standardization of acupuncture points and reproducibility in clinical treatments and research protocols.

Clinically, the current authors also found that the neuroanatomical structures of KI 1 to KI 8 have been indicated in the treatment of certain entrapment syndromes of the foot (e.g., MTTS) and syndromes involving the ANS (e.g., OAB syndrome). Taken together, future studies should explore the use of the Kidney channel clinically as an adjunct treatment or for similar applications.

Finally, the current authors hope that this approach will inspire acupuncturists' interest in studying neuroanatomy so that interprofessional collaboration based on the same medical language is made possible. It will ultimately be in patients' best interest for their healthcare providers to communicate effectively with each other.

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AUTHOR DISCLOSURE STATEMENT

No competing financial interests exist.

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