

## Variations in Innervation Pattern to Dorsum of Foot by Medial Dorsal Cutaneous Nerve, Intermediate Dorsal Cutaneous Nerve, Lateral Dorsal Cutaneous Nerve with Surgical and Clinical Correlations: A Cadaveric Dissection Based Study

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### ABSTRACT

The complete reconstruction of any soft tissue defect includes even the sensory recovery which is very significant aspect pertaining to prognosis. Superficial nerves in the vicinity of the vascular axis can be considered as vascular relays and neuroskin grafts can be constructed on them. Variations in innervation to various part of the dorsum of the foot by this nerve should be kept in mind while making these grafts. Authors dissected 50 formalinized cadaveric feet and studied normal anatomy and variations in origin, course, branching pattern, communications, and any other variations in medial, intermediate and lateral dorsal cutaneous nerve. The intermediate dorsal cutaneous nerve was innervating larger area of the skin around 3<sup>rd</sup> and 4<sup>th</sup> web spaces in 60% of cadaveric feet. The 2<sup>nd</sup> web space was innervated by medial dorsal cutaneous nerve in 92% of cadaveric feet. In 52% of cadaveric feet communicating branches were found between intermediate dorsal cutaneous nerve and lateral dorsal cutaneous nerve. In 63% cadaveric feet communicating branches were found between medial dorsal cutaneous nerve and branch of deep peroneal nerve to 2<sup>nd</sup> web space. The mean distance between lateral malleolus and intermediate dorsal cutaneous nerve was 4.05cm. These all observations can provide anatomical basis at the time of preparing medial dorsal cutaneous nerve flaps and intermediate dorsal cutaneous nerve flaps and also can minimize morbidity at donor site.

**KEY WORDS:** Medial Dorsal Cutaneous Nerve, Intermediate Dorsal Cutaneous Nerve, Lateral Dorsal Cutaneous Nerve, Medial Dorsal Cutaneous Nerve Flap, Intermediate Dorsal Cutaneous Nerve Flap, Soft Tissue Defects, Open Reduction And Internal Fixation Of Fibula, Arthroscopy, Local Anesthetic Block, First Dorsal Metatarsal Artery Flap, Defects In Distal Dorsalis Pedis, Compression And Entrapment Neuropathies.

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### INTRODUCTION

The complete reconstruction of any soft tissue defect includes even the sensory recovery which is very significant aspect pertaining to prognosis [1]. The vascular axis,

which can either be an artery or anastomosis between arteries which forms a minute network, can provide nourishment to nerve in its vicinity. This vascular axis also provides several cutaneous branches accompanying

cutaneous nerves in the suprafascial region. They also anastomose with the septocutaneous arteries which are branches of deep arteries in the same region. Looking at this scenario, superficial nerves in the vicinity of this vascular axis can be considered as vascular relays. By applying this concept, the neuroskin island flaps can be developed [2,3]. Medial dorsal cutaneous nerves flap and intermediate dorsal cutaneous nerves flap can be used to cover soft tissue defects on middle of the dorsum of the foot and also for small sized skin and soft tissue defects in distal dorsalis pedis [4,5].

The intermediate dorsal cutaneous nerve flap can also be used as an alternative and effective technique to cover soft tissue defects on toes and web spaces. It has the advantage of minimal donor site morbidity and the artery need not be sacrificed [5].

First dorsal metatarsal artery flap which consists of the branch of deep peroneal nerve to the first web space has also proved to restore sensory functions in reconstructing the soft tissue defect on great toe [6].

The superficial peroneal nerve and sural nerve innervates the skin of the dorsum of the foot with small contribution by branch from deep peroneal nerve which innervates area around first web space. The superficial peroneal nerve divides into medial and intermediate dorsal cutaneous nerve. Their origin points or location is variable. The sural nerve gives out the lateral dorsal cutaneous nerve. Its innervation pattern is also variable [7].

Intermediate dorsal cutaneous nerve is at risk while performing ankle arthroscopy [8].

Having well acquainted with information about variations in cutaneous innervation to the dorsum of the foot, can minimize unnecessary complications at the donor and recipient sites. It can also minimize chances of damaging these structures while doing some operatives as open reduction and internal fixation of fibula, performing arthroscopy, while applying some external fixators. This information is useful for the plastic surgeons for elevation of flaps on medial and intermediate dorsal cutaneous nerves, and also to raise flaps based on first

dorsal metatarsal artery. It can be of great help to anesthetics while giving local anesthetic block [8-14].

There are studies done by authors Cheredath et al [15], Inchai, Vaseenon, et al [16], V Nayak, et al [17] which describe the innervation pattern on dorsum of the foot according to the areas supplied by sural nerve, superficial perineal nerve and deep perineal nerve. Carla Gabrielli et al [18] have studied the topographic anatomy of superficial perineal nerve on dorsum of the foot. C Madhavi et al [19] studies cutaneous innervation of dorsum of the foot in relation with only sural nerve. We were unable to find study which describes normal anatomy and variations in individual medial, intermediate and lateral dorsal cutaneous nerves.

In this decade of minimal invasive, noninvasive interventions, arthroscopic surgeries, and regional anesthesia, coming up with information about innervation by individual cutaneous branch, is of more relevance. So, we studied gross anatomy of the individual branches as medial dorsal cutaneous nerve, intermediate dorsal cutaneous nerve, lateral dorsal cutaneous nerve.

## MATERIALS AND METHODS

**Materials:** Dissection kit, Nikon COOLPIX P80 camera, fifty formalinized human cadaveric feet procured from the department of Anatomy Dr D Y Patil Medical College, Hospital and Research centre, Dr D Y Patil Vidyapeeth, Pune, Maharashtra, India.

**Methods:**

**Study design:** Descriptive study

**Study population:** Western Indian human cadavers

**Duration of study:** Two years

**Sample size:** Fifty formalinized human cadaveric feet procured from the department of Anatomy Dr D Y Patil Medical College, Hospital and Research centre, Dr D Y Patil Vidyapeeth, Pune, Maharashtra, India.

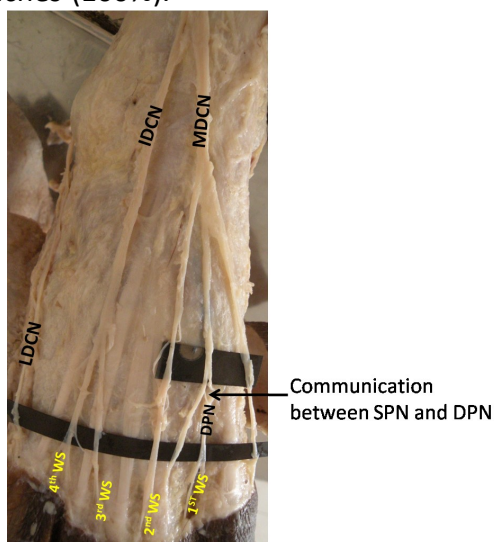
**Inclusion criteria:** Adult formalinized human cadaveric feet with soft skin of dorsum of the foot.

**Exclusion criteria:** feet with dried and macerated skin on the dorsum, feet with any obvious deformity.

**Procedure details:** The skin of the dorsum of the foot was reflected according to steps of dissection provided in Cunningham's dissection manual for lower extremity [20]. Then the dorsal venous arch was dissected and was sacrificed to dissect and clean the cutaneous nerves. The variation in innervation pattern on the dorsum of the foot by medial, lateral and intermediate dorsal cutaneous nerves were noted. Any communicating branches between medial, intermediate and lateral dorsal cutaneous nerves were noted. Any variations in relation with origin of first, second, third, fourth dorsal digital nerves were noted. The distance between intermediate dorsal cutaneous nerve and tip of the lateral malleolus was measured with the measuring tape and was noted down. Photographs of dissected specimens were taken and labeled.

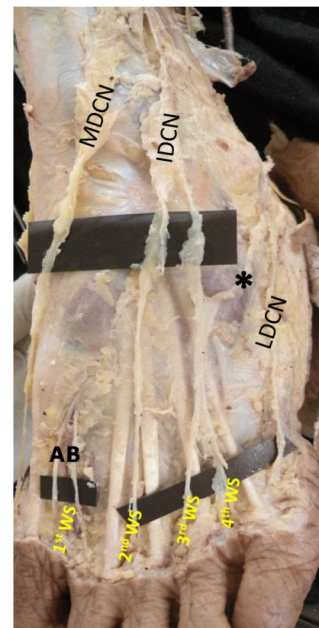
### OBSERVATIONS

In 38 cadaveric feet (76%) the superficial peroneal nerve flattened before dividing into medial and intermediate dorsal cutaneous nerve. In all specimens the medial dorsal cutaneous nerve flattened before dividing into branches (100%).



**Fig. 1:** Branch from deep peroneal nerve is innervating 1<sup>st</sup> web space, 2<sup>nd</sup> web space is innervated by medial dorsal cutaneous nerve, 3<sup>rd</sup> and 4<sup>th</sup> web spaces are innervated by intermediate dorsal cutaneous nerve. The lateral side of 5<sup>th</sup> toe is innervated by sural nerve.

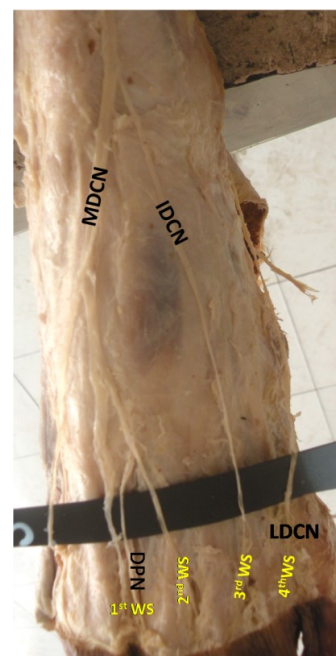
**MDCN:** medial dorsal cutaneous nerve, **IDCN:** intermediate dorsal cutaneous nerve, **DPN:** deep peroneal nerve, **SN:** sural nerve, **WS:** web space



**Fig. 2:** Only medial side of great toe is innervated by medial dorsal cutaneous nerve

**A, B:** Branches from deep peroneal nerve innervating 1<sup>st</sup> web space. 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> web spaces are innervated by intermediate dorsal cutaneous nerve. Only lateral side of 5<sup>th</sup> toe is innervated by lateral dorsal cutaneous nerve.

**MDCN:** medial dorsal cutaneous nerve, **IDCN:** intermediate dorsal cutaneous nerve, **DPN:** deep peroneal nerve, **SN:** sural nerve, **WS:** web space  
\*Communication between sural nerve and intermediate dorsal cutaneous nerve

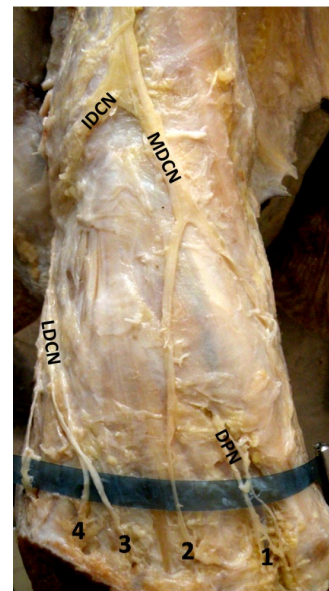


**Fig. 3:** Branch from deep peroneal nerve is innervating 1<sup>st</sup> web space. 2<sup>nd</sup> web space is innervated by medial dorsal cutaneous nerve. Only 3<sup>rd</sup> web space is innervated by intermediate dorsal cutaneous nerve. 4<sup>th</sup> web space is innervated by lateral dorsal cutaneous nerve

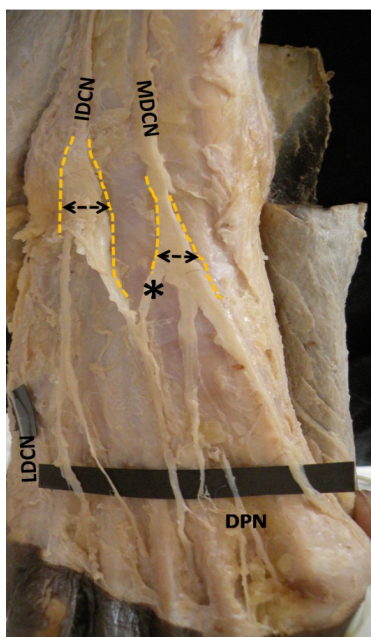
**MDCN:** medial dorsal cutaneous nerve, **IDCN:** intermediate dorsal cutaneous nerve, **DPN:** deep peroneal nerve, **SN:** sural nerve, **WS:** web space



**Fig. 4:** 1<sup>st</sup> web space is innervated by very thin branches of deep peroneal nerve. 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup> web spaces innervated by lateral dorsal cutaneous nerve. Intermediate dorsal cutaneous nerve very thin ending at the level of tip of the lateral malleolus  
**MDCN:** medial dorsal cutaneous nerve, **IDCN:** intermediate dorsal cutaneous nerve, **DPN:** deep peroneal nerve,  
**1:** 1<sup>st</sup> web space **2:** 2<sup>nd</sup> web space, **3:** 3<sup>rd</sup> web space, **4:** 4<sup>th</sup> web space



**Fig. 5:** 1<sup>st</sup> web space is innervated by deep peroneal nerve. 2<sup>nd</sup> web space is innervated by medial dorsal cutaneous nerve. 3<sup>rd</sup>, 4<sup>th</sup> web spaces innervated by lateral dorsal cutaneous nerve. Intermediate dorsal cutaneous nerve ending at the level of tip of the lateral malleolus.  
**MDCN:** medial dorsal cutaneous nerve, **IDCN:** intermediate dorsal cutaneous nerve, **DPN:** deep peroneal nerve,  
**1:** 1<sup>st</sup> web space **2:** 2<sup>nd</sup> web space, **3:** 3<sup>rd</sup> web space, **4:** 4<sup>th</sup> web space



**Fig. 6:** Medial and intermediate dorsal cutaneous nerves. spreading out before dividing into digital branches  
 \* Communication between medial and intermediate dorsal cutaneous nerve  
**DPN:** Deep peroneal nerve, **MDCN:** medial dorsal cutaneous nerve, **IDCN:** intermediate dorsal cutaneous nerve  
**LDCN:** lateral dorsal cutaneous nerve

**Table 1:** Medial dorsal cutaneous nerve innervation pattern on the dorsum of the foot.

Medial dorsal cutaneous nerve innervation pattern on the dorsum of the foot	Number of cadaveric feet showing the variation
Innervating only to medial side of great toe	In 4 feet
Innervating medial side of great toe and 2 <sup>nd</sup> web space	In 43 feet
Innervating medial side of great toe and 2, 3 web space	In 2 feet
Innervating medial side of great toe and 2,3,4 web space	In 1foot
Innervating 3 <sup>rd</sup> web space	In 1 foot

**Table 2:** Intermediate dorsal cutaneous nerve innervation pattern on dorsum of the foot.

Intermediate dorsal cutaneous nerve innervation pattern on the dorsum of the foot	Number of cadaveric feet showing the variation	
	In present study	Gabrielli C at al (17)
Innervating 2 <sup>nd</sup> , 3 <sup>rd</sup> , 4 <sup>th</sup> web spaces	In 4 feet (8%)	14.80%
Innervating 3 <sup>rd</sup> , 4 <sup>th</sup> web spaces	In 30 feet (60%)	77%
Innervating only 4 <sup>th</sup> web space	In 1 foot (2%)	3.70%
Innervating 1 <sup>st</sup> web space	In 2 feet (4%)	-
Absent intermediate dorsal cutaneous nerve	In 10 feet (20%)	-
Ended at the level of tip of lateral malleolus	In 3 feet (6%)	-

**Table 3:** Lateral dorsal cutaneous nerve innervation pattern on the dorsum of the foot.

Lateral dorsal cutaneous nerve innervation pattern on the dorsum of the foot	Number of cadaveric feet showing the variation	Percentage of cadaveric feet showing the variation in various studies		
		Present study	Inchai, et al (16)	C. Madhavi et al(18)
Innervating 2 <sup>nd</sup> , 3 <sup>rd</sup> , 4 <sup>th</sup> web spaces	In 3 feet	6%	Not found	Not found
Innervating 3 <sup>rd</sup> , 4 <sup>th</sup> web spaces	In 12 feet	24%	33.33%	60.7 6%
Innervating 4 <sup>th</sup> web space	In 3 feet	6%	16.67%	13.85%
Innervating only skin of lateral side of 5 <sup>th</sup> toe	In 32 feet	64%	46.30%	35.38%

**Table 4:** Details of communications between various cutaneous nerves innervating dorsum of the foot.

Communications present between	Number of cadaveric feet showing the variation
Medial dorsal cutaneous nerve and branch of deep peroneal nerve to 2 <sup>nd</sup> web space	32 feet
Medial dorsal cutaneous nerve and intermediate dorsal cutaneous nerve and	6 feet
Intermediate dorsal cutaneous nerve innervating 3 <sup>rd</sup> and 4 <sup>th</sup> web spaces and lateral dorsal cutaneous nerve	20 feet
Intermediate dorsal cutaneous nerve to 3 <sup>rd</sup> web space and lateral dorsal cutaneous nerve	1 feet
Intermediate dorsal cutaneous nerve and lateral dorsal cutaneous nerve innervating 2 <sup>nd</sup> , 3 <sup>rd</sup> , 4 <sup>th</sup> web spaces	2 feet
Intermediate dorsal cutaneous nerve and lateral dorsal cutaneous nerve innervating 3 <sup>rd</sup> , 4 <sup>th</sup> web spaces	3 feet
Medial dorsal cutaneous nerve and lateral dorsal cutaneous nerve	2 feet

**Table 5:** Distance between intermediate dorsal cutaneous nerve and tip of the lateral malleolus.

Range of distance between intermediate dorsal cutaneous nerve and tip of the lateral malleolus	Number of cadaveric feet showing the variation
2.4cm to 3cm	3 feet
3cm to 3.5cm	14 feet
3.5cm to 4cm	10 feet
4cm to 4.5cm	15 feet
4.5cm to 5cm	5 feet
5cm to 5.5cm	zero
5.5cm to 6cm	2 feet
6 cm to 6.5cm	1 foot

The mean distance between lateral malleolus and intermediate dorsal cutaneous nerve was 4.05cm.

## DISCUSSION

The intermediate dorsal cutaneous nerve was innervating larger area of the skin around 3<sup>rd</sup> and 4<sup>th</sup> web spaces in 60% of cadaveric feet.

The 2<sup>nd</sup> web space was innervated by medial dorsal cutaneous nerve in 92% of cadaveric feet. In 52% of cadaveric feet communicating branches were found between intermediate dorsal cutaneous nerve and lateral dorsal cutaneous nerve. The same variation is mentioned in a study done by Inchai, Vaseenon, Tanaka, Mahakkanukrauh [16] in 38.46% of cadaveric feet where the sample size was 54.

These variations should be kept mind while making medial, intermediate dorsal cutaneous nerve flaps, first dorsal metatarsal artery flap. Analyzing the innervation pattern on the dorsum of the foot prior to making flap can minimize morbidity at donor site [1-6].

Authors tried to search article related to description of anatomical study on innervation pattern by medial dorsal cutaneous nerve, intermediate dorsal cutaneous nerve and lateral cutaneous nerve on dorsum of the foot. As similar kind of studies are not available, it was not possible to compare the study findings with any other studies.

In 63% cadaveric feet communicating branches were found between medial dorsal cutaneous nerve and branch of deep peroneal nerve to 2<sup>nd</sup> web space. The same variation is noted

by C. Garrielli [17] in 53.35% cadaveric feet. The communicating branches can cause confusion at the time of clinical evaluation to diagnose exactly which nerve is affected in cases of compression or entrapment neuropathies. If the tingling and numbness or any altered sensations are seen over the region between first web space it is difficult to evaluate whether the branch of deep peroneal nerve supplying to the first web space or the branch of superficial peroneal nerve in this space is affected [21].

The information about communicating branches can be of great help while recognizing them for infiltration at the time of giving local anesthesia and also if neurolysis is required to treat certain clinical conditions as compression and entrapment neuropathies when conservative management fails [22].

The mean distance between lateral malleolus and intermediate dorsal cutaneous nerve was 4.05cm. This information can be helpful while doing arthroscopic surgery at ankle to avoid damage to intermediate dorsal cutaneous nerve [8].

These all observations can provide anatomical basis at the time of preparing medial dorsal cutaneous nerve flaps and intermediate dorsal cutaneous nerve flaps.

## CONCLUSION

The intermediate dorsal cutaneous nerve was innervating larger area of the skin around 3<sup>rd</sup> and 4<sup>th</sup> web spaces in 60% of cadaveric feet. The 2<sup>nd</sup> web space was innervated by medial dorsal cutaneous nerve in 92% of cadaveric feet. In 52% of cadaveric feet communicating branches were found between intermediate dorsal cutaneous nerve and lateral dorsal cutaneous nerve. In 63% cadaveric feet communicating branches were found between medial dorsal cutaneous nerve and branch of deep peroneal nerve to 2<sup>nd</sup> web space. The mean distance between lateral malleolus and intermediate dorsal cutaneous nerve was 4.05cm. These all observations can provide anatomical basis at the time of preparing medial dorsal cutaneous nerve flaps and intermediate dorsal cutaneous nerve flaps and also can minimize morbidity at donor site.

## Conflicts of Interests: None

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