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Original Research Article

Evaluation of a Simple Method of Locating Femoral Block Puncture Site Using Finger Width Measurements and Correlation with Ultrasonographic Nerve Artery Distance: A Prospective Cohort Study

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Conflict of interest: Nil

Abstract

Background: Femoral nerve block, a relatively easy and safe peripheral nerve block, provides prolonged and effective perioperative analgesia in lower limb surgeries. A good landmark technique avoids unnecessary needle punctures and complications during block performance. We decided to find a simple technique to locate block puncture site and confirm it with ultrasonography.

Materials and Methods: The aims were to find the correlation between finger width and femoral nerve-artery distance with ultrasonographic imaging, BMI, hip and waist circumferences and femoral nerve depth in Indian population. 360 subjects with planned femoral nerve block or healthy volunteers were studied. Patient's age, height, weight, waist circumference, hip circumference was noted. Finger width of both hands at distal inter-phalangeal joint was measured using vernier's calliper. Femoral nerve-artery distance and nerve depth were measured using ultrasonography.

Results: Finger widths ranged from 1.24± 0.0481 cm to 1.42± 0.0623 cm. The femoral nerve-artery distances were in the range of 1.14 mm to 1.46 mm with median of 1.24 mm. Correlation coefficients between nerve-artery distance and finger width were 0.36 (Right little finger), 0.61 (Right middle finger), 0.44 (Left little finger) and 0.65 (Left index finger). Regression analysis yielded the model NA = 0.18 + 0.86 d with NA as the femoral nerve-artery distance and d the distal inter-phalangeal joint finger width. On simplification owing to the negligible constant (0.18) and multiplier (0.86) being close to one, femoral nerve – artery distance can be said to correspond to distal inter-phalangeal joint finger width of index finger of left hand. An association between BMI>25 kg/m^2 and femoral NA distance (P value =0.0000) and hip circumference and femoral NA distance in males (P value =0.017) was found.

Conclusion: A simplified, individualized landmark approach not requiring any additional, costly technical aids for needle insertion site for femoral nerve block was found. Puncture site should be lateral to the lateral most point of pulsating femoral artery at a distance equivalent to the width of the patient's index finger of the non-dominant hand measured at the distal inter-phalangeal joint. It is especially useful for patients with intermediate BMI values.

Keywords: Femoral Nerve Block, Anthropometric, USG, Callipers, BMI.

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Introduction

Femoral nerve block is a simple, easy to learn, reliable regional anaesthetic technique used in prehospital, in hospital-emergency and elective settings for multiple reasons. It is used to obtain analgesia for femoral trauma, anaesthesia and analgesia for elective procedures like skin grafts from anterior thigh, knee arthroscopy, total knee arthroplasty, surgeries on the medial aspect of the leg, repair of the quadriceps tendon or quadriceps muscle biopsy [1-12]. It is also used along with sciatic nerve block for emergency surgeries of the lower limb, especially in high-risk patients. However, the quality, efficiency and speed of performance depend upon accurate localisation of the puncture site. Hence, despite being a low-cost and reliable technique, it is not widely used in prehospital or emergency settings.

The availability of fast and easily applicable method for puncture site prediction, in the absence of an ultrasonography (USG) machine or nerve stimulators, may benefit distressed trauma patients by promoting femoral nerve block use amongst emergency room non-anaesthesia and anaesthesia personnel. Block puncture site is generally determined using anatomical landmarks or ultrasonography. Punctures of landmark-guided techniques are routinely performed at a fixed distance from an anatomical landmark i.e. lateral to the palpable pulse of the femoral artery [13-16] (Fig. 1).

However, this distance determined on the basis of cadaveric studies, changes as per the anatomical variations in different individuals and may affect the first puncture success rate. Using an anatomical measuring tool individualised to the particular patient may increase the probability of obtaining a successful first puncture and subsequently affect the block success rate.

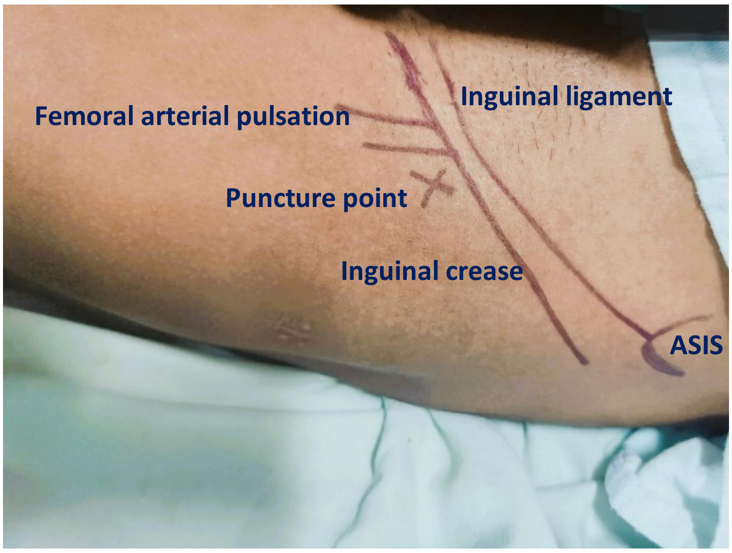

Figure 1: Landmark guided puncture site for femoral nerve block

Cadaveric [17-19] and imaging studies [20] have been done in the past to accurately determine the point of puncture for femoral nerve block. A recent ultra-sonographic anatomical-anthropometric study [21] found that the distance from the midpoint of the visualised femoral artery to the femoral nerve projected to the skin closely corresponded to the width of the fifth finger of the dominant hand measured at the distal interphalangeal joint.

However, practitioners routinely use a puncture point at a fixed distance from the lateral most point of the pulsating femoral artery to avoid trauma to the femoral artery. Hence the authors proposed to measure distance from the lateral most edge of the femoral artery to the centre of the femoral nerve under ultrasonographic guidance and find the association of finger widths of the distal inter phalangeal joint of both hands with the femoral artery-nerve distance using ultrasonography in Indian population. The secondary objectives were to find the depth of femoral nerve, and the association between Body Mass Index (BMI), hip and waist circumferences and the femoral artery-nerve distance, if any.

Material and Methods

The prospective observational cohort study was conducted at Lokmanya Tilak Municipal General Hospital, Mumbai, Maharashtra, India, from December 2019 to December 2020 after approval from the Institutional Ethics Committee (IEC/529/19). The sample size was calculated to be 385 using the social science statistics online sample size calculator with an expected precision level of +/- 5%, a confidence level of 95% and an estimated population variability proportion of 0.5 %. All consenting adults between 18 and 80 years age, of either sex, posted for ultrasonographic guided femoral nerve block or any other procedure and willing for ultrasonographic examination of femoral area and finger width measurement were invited to participate in the study. Patients with absence of fingers of any hand distal to proximal interphalangeal joint or those with infection, injury or bleeding over the bilateral femoral area were excluded. Informed consent was obtained with an explanation about the study and perioperative data collection. Height, weight, waist circumference and hip circumference of patients were noted and BMI was calculated. The width of distal inter-phalangeal joints of all fingers of both hands was measured using vernier callipers (Fig. 2).

Figure 2: Vernier callipers to measure finger width

Ultrasonographic measurement of femoral nerve-artery distance (NA) was noted using the following technique. Patient was placed in a supine position with the leg abducted to 5 degrees.

A linear ultrasound probe (Samsung Medison, SonoAce R7) was kept parallel to the inguinal crease at right angles to the patient's vertical axis to obtain the short axis of the nerve within the triangular hypoechoic region. USG imaging was performed with no pressure being exerted on probe to reduce the possibility of anatomical alterations due to probe manipulation. Femoral nerve and artery were identified.

The callipers were placed at the lateral most edge of the femoral artery and centre of the femoral nerve and the distance was measured and noted (Fig. 3). The depth of femoral nerve from skin was also noted.

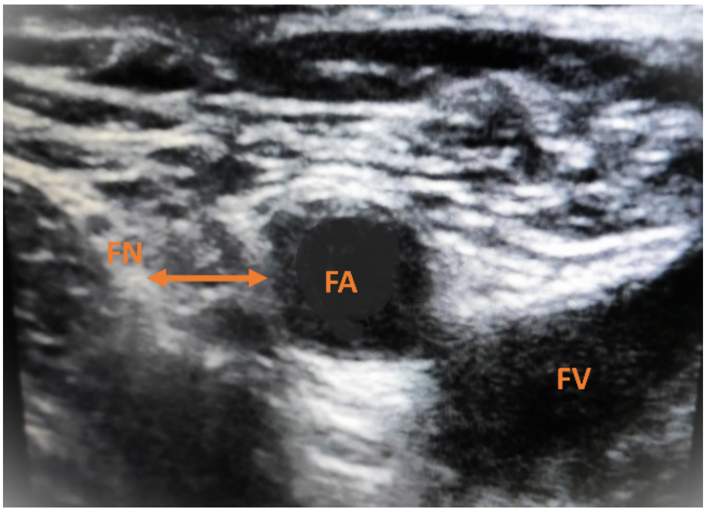

Figure 3: Ultrasonographic measurement of distance from femoral nerve to lateral wall of femoral artery

280 patients and 105 healthy volunteers were recruited for the study using a consecutive, convenient sampling method. Healthy volunteers had to be recruited as elective cases were curtailed due to the COVID pandemic. 25 subjects were excluded from the final analysis because of incomplete data, either due to operator inexperience or unavailability of the USG machine. (Fig 4)

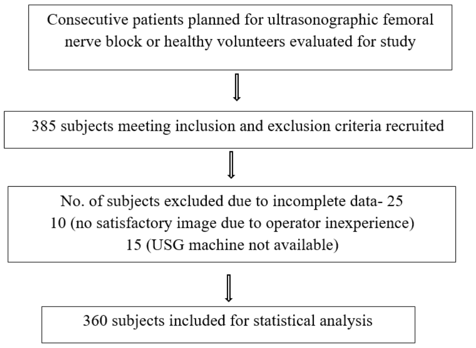

Figure 4: Flowchart of methodology

Statistical Analysis: Data was entered into Microsoft Excel (Windows 7, Version 2007) and analysis was done using the Statistical Package for Social Sciences (SPSS) for Windows software (version 24.0; SPSS Inc, Chicago). Mean and standard deviation (SD) for continuous variables, frequencies and percentages for categorical variables were determined. Association between categorical variables was analysed using Chi-Square test. Levenes test was used to test if the samples have equal variance to test the homogeneity of the data. Graphs were made by Microsoft Excel (Version 14). Pearson's correlation was used to test the correlation between inter-phalangeal distances and ultrasonographically measured nerve artery distance, BMI, Hip circumference and waist circumference. The level of significance was set at 0.05.

Results

The demographic details of the 360 patients are as shown in Table 1.

Table 1: Demographic details

Demography	Mean ± Std. Deviation
Age (years)	50.06 ± 14.535
Male: Female	191(53.1 %):169 (46.9 %)
Right-handed: Left-handed	347 (96.4 %):13 (3.6 %)
Height (in cm)	158.31 ± 6.513
Weight in kg)	57.81 ± 10.890
BMI (in kg/m^2)	23.29 ± 4.5023
BMI- underweight/normal/overweight	30/231/99
Waist circumference (cm)	77.61 ± 6.263
Hip circumference (cm)	85.93 ± 6.117

Table 2: Distances, width measurements and correlations

Measurements	Mean ± SD	Median	Min	Max		
Femoral nerve-artery distance (cm)	1.25± 0.6303	1.24	1.14	1.46		
Depth of femoral nerve (cm)	2.71± 0.4097	2.75	1.70	3.65		
Distal inter-phalangeal joint widths for Right hand					**Pearson Correlation (r) between Finger width and Femoral nerve-artery distance**	**p value**
Index finger	1.26± 0.0502	1.2600	1.10	1.36	0.572**	0.000
Middle finger	1.27± 0.0699	1.3000	1.12	1.37	0.617**	0.000
Ring finger	1.27± 0.0645	1.2800	1.16	1.38	0.597**	0.000
Little finger	1.17 ± 0.647	1.1800	1.02	1.28	0.481**	0.000
Thumb	1.40 ± 0.965	1.4000	1.12	1.56	0.365**	0.000
Distal inter-phalangeal joint widths for Left hand						
Index finger	1.24± 0.0481	1.2400	1.10	1.34	0.572**	0.000
Middle finger	1.27± 0.0685	1.2800	1.12	1.37	0.617**	0.000
Ring finger	1.27± 0.0868	1.3200	1.10	1.41	0.597**	0.000
Little finger	1.18± 0.0505	1.1800	1.08	1.28	0.481**	0.000
Thumb	1.42± 0.0623	1.4200	1.30	1.54	0.365**	0.000

The femoral artery nerve distance, depth of femoral nerve, distal phalangeal widths and correlations are mentioned in Table 2. As the statistically strongest correlation was observed for the index finger of the left hand, this data set was selected for further statistical analysis. In Fig. 4, the Nerve- Artery distance versus width of index finger of left hand (shown as the solid black line) is plotted for all 360 patients. We attempted to find an exact relation between the femoral nerve-artery distance and the distal inter-phalangeal joint width by mathematical equation using regression analysis (Table 3). Regression analysis provided the relation NA distance = 0.18 + 0.86 d (d is distal inter-phalangeal joint width in cm); which can be simplified to 0.2 + 0.9 times d in cm, where d is distal inter-phalangeal joint finger width in cm. The difference of 1mm between 0.9 times d and 1 times d can be safely ignored, as can the 0.2, which contributes to an insignificant increase in the ultimate nerve artery distance. Thus, the Femoral nerve – artery distance can be said to correspond to the distal inter-phalangeal joint finger width of the index finger of the left hand.

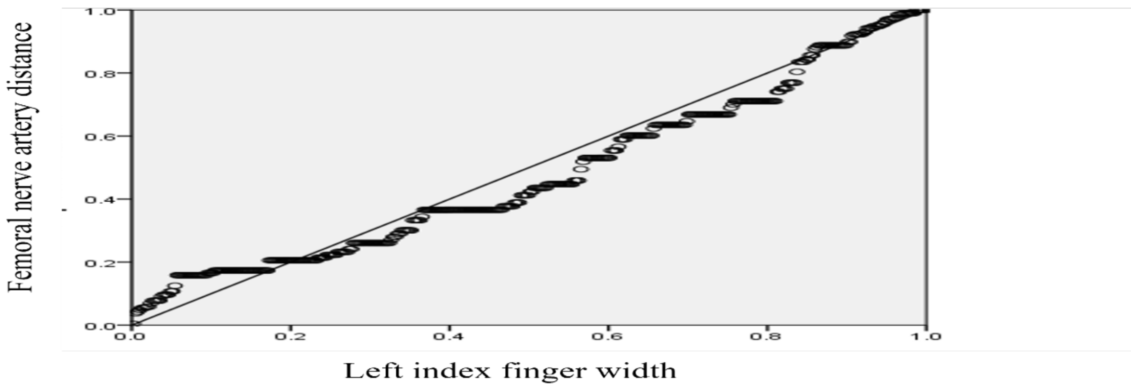

Figure 4: Nerve-artery distance (NA) plotted against left index finger distal interphalangeal joint width for all 360 subjects

Table 3: Model correlating NA distance with left index finger width using regression analysis

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
	B	Std. Error	Beta			Lower Bound	Upper Bound
(Constant)	0.182	0.065		2.795	0.005	0.054	0.310
Left index finger	0.857	0.052	0.655	16.381	0.000	0.754	0.960

There was a strong association between BMI and femoral nerve-artery distance especially in BMI>25 patients (P value =0.0000) but not with the finger width of the left index finger as there was less variation in finger width. There was a positive association between hip circumference and femoral nerve-artery distance in males (P value =0.017). Since only 5 females had greater than normal hip circumference, association could not be determined. Waist circumference was not significantly related to femoral nerve-artery distance in females (P value =0.072), while lack of variation in males led to no association being found.

Discussion

Femoral nerve block is a relatively easy and safe peripheral nerve block to perform. It can provide the patient with prolonged and effective perioperative analgesia for lower limb surgery. It has wide indications, both in pre-hospital and in hospital settings. It requires a good landmark strategy to avoid unnecessary needle punctures and complications during block performance. In traditionally used anatomical landmark-guided and peripheral nerve stimulator-guided blocks, multiple needle punctures are often required. Inadvertent puncture to vascular and neural structures also limits the number of attempts and hence success rates. Ultrasonography-guided nerve block has shown high success with a low complication rate in regional analgesia but nerve and intravascular injury are not uncommon [22,23]. USG may also be limited by the costs of the equipment and expertise required for performing the procedures [24,25]. Speedy and accurate interventions are needed in emergency setups. So, landmark-guided femoral nerve block is the most feasible method to use [26,27]. It is important to have accurate information regarding the puncture site to achieve optimal analgesia and a reduction of the patient's discomfort. Cadaveric anthropometric studies [17-19] or MRI-based studies [20] have been performed to find the point of puncture for femoral nerve block. In 1999 Vloka - J D et al, [17] conducted the first cadaveric study to compare the frequency of needle- femoral nerve contacts on single needle insertion at four frequently used insertion sites on the lower extremity of nine adult cadavers in the supine position. It was found that the high frequency of needle-nerve contact was achieved when the needle was inserted on the inguinal crease immediately lateral to the femoral artery and the femoral nerve was more superficial at the level of inguinal crease. Choudhury S et al, in 2019 [19], performed a cadaveric anthropometric study of femoral nerve in 54 formalin fixed cadavers and showed a weak negative correlation between the width of distal inter-phalangeal joint of little finger of the same side with femoral nerve-artery distance. However, results based on cadaver studies have various types of limitations. Embalming involves collapsed vascular structures and altered body water content and cadavers show tissue distortion and shrinkage. Hence, the results cannot be correlated clinically [17.28]. Mechanical manipulations during dissection alter the anatomical relations of various structures [28]. It is therefore necessary to perform in vivo studies to perfect landmark-guided femoral nerve block.

One such in vivo study evaluated the correlation of finger width with ultrasonographical femoral artery-nerve distance [21]. In 2015, Frkovic V et al, conducted a study in 67 patients posted for elective surgery and found an individualized approach in determining puncture site for femoral nerve block. They found the correlation coefficients for nerve-artery distance and finger width to range from 0.43 for finger 3 to 0.66 for finger 5 in the dominant hand. The distance from femoral artery to the femoral nerve projected to skin closely corresponded to width of fifth finger of the dominant hand at the distal interphalangeal joint.

However, the authors' study of 360 Indian subjects found correlation coefficients for nerve-artery distance and finger width to range from 0.36 for little finger to 0.61 for middle finger for right hand and from 0.44 for little finger to 0.65 for index finger. The exact relation between femoral nerve-artery distance and the distal inter-phalangeal joint width of the index finger of the left-hand calculated using regression analysis provided the relation as NA = 0.18 + 0.86d. This was further simplified to one times the width as the constant was negligible and multiplier was close to unity. The femoral nerve – artery distance was thus said to correspond to the distal inter-phalangeal joint finger width of the index finger of the non-dominant hand.

We attempted to analyse the reasons for our finding of the left index finger as the anatomical measure as compared to the Frkovic V et al, study where the little finger width was sufficient as measure of nerve artery distance. The variation may be due to the differences in sample size, age, height, BMI and ethnicity. Our method of measuring the nerve from the lateral most point of the femoral artery as against the midpoint considered by the study authors may also have played a role. Moreover, our study was conducted in 360 subjects, while the Frkovic study had 67 patients.

The smaller sample size in the previous study may have skewed the outcome in favour of the little finger. Age groups included in our study were in the range of 21 to 79 years with average of 49 yrs, while the previous anthropometric study included patients between 18 and 98 years with a mean of 48 years with a higher number of geriatric patients. So, age-related muscle atrophy and fat loss in the geriatric population could have affected the results. In our study, height ranged from 145 cm – 170 cm as against 154 - 197 cm and a weight 36-83 kg as against a weight of 48 - 115 kg in the Frkovic study. Additionally, the BMI of subjects ranged from 14.38 to 36.44 with a mean of 22.89 as compared to the previous anthropometric study where subjects with BMI from 17 to 32.9 with a mean of 25 were included. So, taller patients and a larger number of overweight and obese subjects were included in their study. This could have affected the finger width distances and the femoral nerve-artery distances due to an accumulation of fat in the inguinal region.

The mean depth of the femoral nerve was 2.71± 0.4097 cm which signifies that a high chance of needle – femoral nerve contact can be achieved at an average depth of 2.75 cm.

Nerve-artery distances in the range of 1.14 cm to 1.46 cm with a mean of 1.24 cm were observed for 360 patients as compared to Frkovic et al who showed nerve-artery distances in the range 0.82 to 2.01 cm with a median of 1.33 cm. As femoral nerve-artery distance was measured from centre of the femoral artery, higher values were observed in their study.

We found that the BMI has a statistically significant correlation with the femoral nerve-artery distance especially in patients with a BMI > 25 kg/m2. Frkovic MD et al, also suggest a negative impact of a high BMI in landmark-guided anaesthesia techniques in their study population. They suggest that their results are mostly applicable to the intermediate BMI group. Underweight or overweight BMI subjects may need a nerve stimulator or an ultrasonography- guided technique for femoral nerve block. This could likely be due to differences in fat tissue accumulation, with excess body tissue in the femoral region i.e. additional soft tissue between the femoral nerve and the artery in the overweight group. Our study found that there was no correlation between underweight, normal, and overweight BMI groups with finger width at the distal inter-phalangeal joint.

Studies have observed difficulties in performing regional anaesthesia in obese patients due to anthropometric changes associated with a higher BMI that reduce the success rate of nerve blocks [29,30]. Schroeder K et al, in 2012 [30] in a retrospective study of 528 patients who received pre-operative USG-guided inter-scalene nerve block studied the association with BMI. It was found that USG-guided inter-scalene block for perioperative analgesia can be safely and effectively performed in obese patients but may be more difficult and analgesia may incomplete.

Limitation

The correlation of finger width with the actual block performance was not studied. There were insufficient patients with BMI > 25 kg/m2 and abnormal hip or waist circumferences. Hence, a correlation between finger width and femoral nerve-artery distance in these subjects could not be studied.

Conclusion

The study demonstrates that the femoral nerve block puncture site can be located with good accuracy by inserting the needle laterally from the lateral most point of the pulsating femoral artery at a distance equivalent to the width of the patient's index finger of the non-dominant hand measured at the distal inter-phalangeal joint.

This gives a fast and simple approach not requiring any additional, costly technical aids and is thus useful in prehospital and emergency situations. It can improve the use and efficacy of routine femoral nerve blockade, allowing for shorter block performance times, decreased complication rates, and increased patient comfort and satisfaction. It constitutes a simplified and individualized approach in locating the needle insertion site, especially for patients with intermediate BMI values.

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