CLINICAL AND ANATOMICAL COMPARISON OF THE FIBULAR NERVE IN GERDY’S SAFE ZONE

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ABSTRACT

Objective: To clinically and anatomically compare the limits of the fibular nerve in Gerdy’s safe zone in cadavers. Methods: Fifty anatomical knee specimens were clinically measured (before dissection) to determine the distances and angles between Gerdy’s tubercle and the posterior region of the fibula (cm); the angle between the line corresponding to the posterior region of the fibula and the tibial crest (degrees); and the angle between Gerdy’s tubercle and the tibial crest (degrees). After dissection of the anatomical specimens, the knees were measured again, to determine the distances and angles between Gerdy’s tubercle and the fibular nerve (cm); the angle between the fibular nerve, in the posterior region of the fibula, and the tibial crest (degrees); and the angle between Gerdy’s tubercle and the tibial crest (degrees). Results: There was a significant increase in the distance between Gerdy’s tubercle and the posterior region of the fibula (cm), after dissection: an average of 0.26 cm (p = 0.018), corresponding to 8.6% (p = 0.007). There was also a significant reduction in the angle between the posterior region of the fibula and the tibial crest after dissection: an average of 3° (p = 0.047), corresponding to 2.1% (p = 0.06). Conclusion: Despite the difference from before to after dissection, Gerdy’s safe zone can be considered safe for orthopedic procedures involving the proximal region of the tibia, thereby avoiding damage to the fibular nerve and its branches.

Keywords – Fibular nerve; Dissection; Cadaver; Tibia

INTRODUCTION

The surgical anatomy of the fibular nerve and its distribution has been well documented(1-5). However, when compared through anatomical dissection, the descriptions of the nerve path are purely generic(4). Most of these studies have described the nerve and its branches linearly and bidimensionally in relation to the head of the fibula and in relation to the proximal region of the tibia. Hence, the spatial relationships of the nerve are difficult to understand(4,5). The fibular nerve supplies motor innervations to the muscles of the anterior compartment of the leg. The two most important functions are ankle dorsiflexion and toes extension, which are both principal components of normal gait. In the proximal region of the tibia, lesions of the fibular nerve may produce serious complications(6-8).

The aim of the present study was to clinically and anatomically compare the limits of the fibular nerve in Gerdy’s safe zone.

METHODS

Fifty knees from cadavers were used, at Petrópolis School of Medicine and at the “Prof. Dr. Donato D’Ángelo” Orthopedics and Traumatology Service, Hospital de Ipanema, Rio de Janeiro, Brazil. Work performed at Petrópolis School of Medicine and at the “Prof. Dr. Donato D’Ángelo” Orthopedics and Traumatology Service, Hospital Santa Teresa, Petrópolis, RJ, Brazil. Correspondence: Av. Roberto Silveira, 187, apto. 601, 25685-040 Petrópolis, RJ. E-mail: plabronici@globo.com

We declare that there is no conflict of interest in this paper.
lis School of Medicine, RJ. Knees with deformities, previous dissection or signs of fracture were excluded. Among the anatomical specimens, 24 were from the right side and 26 from the left side; 45 were male and five were female. The anatomical knee specimens were measured clinically (before dissection) in order to determine the distances and angles between Gerdy’s tubercle and the posterior region of the fibula (cm); the angle between the line corresponding to the posterior region of the fibula and the tibial crest (degrees); and the angle between Gerdy’s tubercle and the tibial crest (degrees). After dissection of the anatomical specimens, the knees were measured again, to determine the distances and angles between Gerdy’s tubercle and the fibular nerve (cm); the angle between the fibular nerve, in the posterior region of the fibula, and the tibial crest (degrees); the angle between Gerdy’s tubercle and the tibial crest (degrees), the proximal region of the fibula and the emergence of the fibular nerve laterally (cm); the angle between the nerve and the fibular axis (degrees); the distance between the proximal region of the fibula and the start of nerve ramification (cm); the distance between Gerdy’s tubercle and the recurrent anterior branch (cm); and the number of branches of the fibular nerve (Figures 1 and 2).

Statistical methodology

The statistical analysis was performed using the Wilcoxon signed rank test, in order to evaluate the absolute and relative variation in the measurements on the fibular nerve, on the lateral face of the knee before and after the dissection. A nonparametric test was applied, since the measurements analyzed did not present normal (Gaussian) distribution. The criterion used for determining significance was the level of 5%. The statistical analysis was processed using the SAS 6.04 software (SAS Institute, Inc., Cary, NC, USA).

RESULTS

Our study had two main objectives: to analyze the anatomical positioning of the fibular nerve and to investigate whether there was any variation between the measurements made before and after the dissection of the 50 anatomical specimens, taking the limit of Gerdy’s tubercle.

Objective 1: General profile of the sample

This study had the aim of outlining a general profile for the 50 anatomical specimens. Table 1 presents the mean, standard deviation (SD), median, minimum and maximum values for the variables analyzed.

Table 1 – General description of the variables analyzed

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>Median</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance between proximal region and nerve emergence (cm)</td>
<td>50</td>
<td>2.43</td>
<td>0.43</td>
<td>2.5</td>
<td>1.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Angle between nerve and axis (degrees)</td>
<td>50</td>
<td>23.90</td>
<td>8.35</td>
<td>20</td>
<td>14</td>
<td>52</td>
</tr>
<tr>
<td>Distance between proximal region and start of ramification (cm)</td>
<td>50</td>
<td>2.23</td>
<td>0.63</td>
<td>2.2</td>
<td>1.2</td>
<td>5</td>
</tr>
<tr>
<td>Distance between GT and start of ramification (cm)</td>
<td>50</td>
<td>4.71</td>
<td>0.50</td>
<td>4.6</td>
<td>3.8</td>
<td>5.5</td>
</tr>
<tr>
<td>Distance between GT and anterior branch (cm)</td>
<td>50</td>
<td>4.45</td>
<td>0.52</td>
<td>4.4</td>
<td>3.5</td>
<td>5.5</td>
</tr>
<tr>
<td>Number of fibular branches</td>
<td>50</td>
<td>3.14</td>
<td>0.70</td>
<td>3</td>
<td>2</td>
<td>5</td>
</tr>
</tbody>
</table>

SD: standard deviation; GT: Gerdy’s tubercle
Source: Petrópolis School of Medicine
maximum of the variables analyzed. Among the 50 anatomical specimens, 45 (90%) were male and 26 (52%) were from the left side.

**Objective 2**: To investigate whether there was significant variation in the measurements, from before to after the dissection.

Tables 2, 3 and 4 present the mean, standard deviation/standard error (SD/SE), median, minimum and maximum of measurements 1, 2 and 3, respectively, before and after the dissection, along with the corresponding absolute delta and relative delta (%) and their respective descriptive level (p) from the Wilcoxon signed rank test.

**Table 2** – Analysis on the change in measurement 1 from before to after the dissection

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th>Mean</th>
<th>SD/SE</th>
<th>Median</th>
<th>Minimum</th>
<th>Maximum</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement 1 before (cm)</td>
<td>50</td>
<td>4.17</td>
<td>0.58</td>
<td>4.2</td>
<td>2</td>
<td>5.2</td>
<td></td>
</tr>
<tr>
<td>Measurement 1 after (cm)</td>
<td>50</td>
<td>4.43</td>
<td>0.42</td>
<td>4.45</td>
<td>3.7</td>
<td>5.5</td>
<td></td>
</tr>
<tr>
<td>Absolute delta (cm)</td>
<td>50</td>
<td>0.26</td>
<td>0.09</td>
<td>0.20</td>
<td>-1.1</td>
<td>2</td>
<td>0.018</td>
</tr>
<tr>
<td>Relative delta (%)</td>
<td>50</td>
<td>8.64</td>
<td>2.95</td>
<td>4.76</td>
<td>-22.4</td>
<td>100</td>
<td>0.007</td>
</tr>
</tbody>
</table>

SD: standard deviation; SE: standard error, only for the delta values Source: Petrópolis School of Medicine

**Table 3** – Analysis on the change in measurement 2 from before to after the dissection

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th>Mean</th>
<th>SD/SE</th>
<th>Median</th>
<th>Minimum</th>
<th>Maximum</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement 2 before (degrees)</td>
<td>50</td>
<td>121.2</td>
<td>12.4</td>
<td>120</td>
<td>105</td>
<td>175</td>
<td></td>
</tr>
<tr>
<td>Measurement 2 after (degrees)</td>
<td>50</td>
<td>118.3</td>
<td>14.0</td>
<td>112</td>
<td>100</td>
<td>170</td>
<td></td>
</tr>
<tr>
<td>Absolute delta (degrees)</td>
<td>50</td>
<td>-2.98</td>
<td>1.79</td>
<td>-2.0</td>
<td>-28.0</td>
<td>33.0</td>
<td>0.047</td>
</tr>
<tr>
<td>Relative delta (%)</td>
<td>50</td>
<td>-2.11</td>
<td>1.45</td>
<td>-1.8</td>
<td>-21.9</td>
<td>29.5</td>
<td>0.060</td>
</tr>
</tbody>
</table>

SD: standard deviation; SE: standard error, only for the delta values Source: Petrópolis School of Medicine

**Table 4** – Analysis on the change in measurement 3 from before to after the dissection

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th>Mean</th>
<th>SD/SE</th>
<th>Median</th>
<th>Minimum</th>
<th>Maximum</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement 3 before (degrees)</td>
<td>50</td>
<td>31.3</td>
<td>8.0</td>
<td>30</td>
<td>18</td>
<td>54</td>
<td></td>
</tr>
<tr>
<td>Measurement 3 after (degrees)</td>
<td>50</td>
<td>29.8</td>
<td>7.5</td>
<td>28</td>
<td>20</td>
<td>48</td>
<td></td>
</tr>
<tr>
<td>Absolute delta (degrees)</td>
<td>50</td>
<td>-1.52</td>
<td>1.19</td>
<td>-2.0</td>
<td>-26.0</td>
<td>20</td>
<td>0.14</td>
</tr>
<tr>
<td>Relative delta (%)</td>
<td>50</td>
<td>-0.98</td>
<td>4.07</td>
<td>-6.3</td>
<td>-54.2</td>
<td>80</td>
<td>0.29</td>
</tr>
</tbody>
</table>

SD: standard deviation; SE: standard error, only for the delta values Source: Petrópolis School of Medicine

Measurement 1 was the distance between Gerdy’s tubercle and the posterior region of the fibula (cm); measurement 2 was the angle between the posterior region of the fibula and the tibial crest (degrees); and measurement three was the angle between Gerdy’s tubercle and the tibial crest (degrees).

The absolute delta was calculated from the following formula:

\[
\text{Absolute delta} = (\text{after dissection} - \text{before dissection})
\]

The relative delta (%) was calculated from the following formula:

\[
\text{Relative delta} (%) = \left(\frac{\text{after dissection} - \text{before dissection}}{\text{before dissection}}\right) \times 100
\]

It was observed in this sample that there was a significant increase in the distance from Gerdy’s tubercle to the posterior region of the fibula (cm) after the dissection, by an average of 0.26 cm (p = 0.018), which corresponded to 8.6% (p = 0.007), as shown in Figure 3.

**Figure 3** – Measurement 1 before and after the dissection

It was observed in this sample that there was a significant decrease in the angle between the posterior region of the fibula and the tibial crest after the dissection, by an average of 3° (p = 0.047), which corresponded to 2.1% (p = 0.06), as shown in Figure 4.
It was observed in this sample that there was no significant variation in the angle between Gerdy’s tubercle and the tibial crest after the dissection. There was an average decrease of 1.5° ($p = 0.14$), which corresponded to 0.98% ($p = 0.29$).

**DISCUSSION**

A variety of diseases may present in the proximal third of the tibia and require intervention by orthopedic surgeons. Among these are proximal osteotomy of the tibia to treat varus deformity secondary to knee osteoarthritis; treatment for fractures using external fixators; fasciectomy following compartment syndrome of the leg; percutaneous biopsy at the level of the proximal region of the fibula; and osteotomy of the fibula. Thus, anatomical knowledge is very important, since damage to the fibular nerve may have serious functional consequences. However, most papers presenting anatomical studies have described the location of the fibular nerve only linearly, in two dimensions, and in relation to the head of the fibula. This makes it very difficult to undertake preoperative planning relating to this nerve.

Kirgis and Albrecht developed a longitudinal scale in millimeters measured starting from the deep trunk of the fibular nerve that illustrates the regions at high and low risk of intraoperative injuries to the fibular nerve.

Stitgen et al described the anatomy of the branches of the common fibular nerve as a “safe zone” for placement of percutaneous wires at the level of the proximal region of the tibia. This safe zone is located in the region anterior to the fibula and 2 cm from its end, thus creating an estimated area of 4 cm$^2$. Takeda et al defined a safe zone for performing biopsies at the level of the proximal region of the fibula. In their study, the nerve was seen crossing the proximal diaphysis of the fibula, thereby forming an angle of 23°.

Moskovich carried out anatomical dissections in an attempt to map out the path of the fibular nerve. To obtain these measurements, Moskovich marked the nerve with lead sutures and produced radiographs. In an illustration in his paper, he showed how the nerve and its recurrent anterior branch described a circle around Gerdy’s tubercle.

According to Rubel et al, the safe zone at the level of the proximal region of the tibia, using Gerdy’s tubercle as the limit, could easily be identified and marked out before the operation. However, it has to be borne in mind that identifying Gerdy’s tubercle becomes more difficult in patients with fractures of the proximal third of the tibia, with severe edema, in patients with previous deformities or in obese patients.

The distance between Gerdy’s tubercle and the head of the fibula determines the radius of this safe zone. The path of the fibular nerve remains constant and forms a radius of approximately 100°, starting at the head of the fibula and finishing at the tibial crest. Our results demonstrated that when we used Gerdy’s tubercle as the limit, there was a significant difference in the anatomical specimens, from before to after the dissection (121.2° before dissecting and 118.3° after dissecting). The average increase in the distance after dissection was 0.26 cm ($p = 0.018$), which corresponded to 8.6% ($p = 0.007$) of the radius between Gerdy’s tubercle and the posterior proximal region of the fibula. Furthermore, the average decrease in the angle between the posterior region of the fibula and the tibial crest was 3° ($p = 0.047$), which corresponded to 2.1% ($p = 0.06$). In our investigations and in other studies, no branches of the fibular nerve have been found in this area.

**CONCLUSION**

Despite the difference in radius between Gerdy’s tubercle and the proximal posterior region of the fibula and the difference in angle between the posterior region of the fibula and the tibial crest, from before to after the dissection, Gerdy’s safe zone can be considered safe for orthopedic procedures in the proximal region of the tibia, thereby avoiding damage to the fibular nerve and its branches.
REFERENCES