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# Morphometric Study of Nutrient Foramina of Dry Human Clavicles in Goan Population

Siddhesh Prakash Prabhu<sup>1</sup>, Sulekha Mangesh Kolap<sup>2</sup>, Uday Narayan Kudalkar<sup>3</sup>

<sup>1</sup>Assistant Professor, Department of Anatomy, Goa Medical College, Bambolim; <sup>2</sup>Lecturer, Department of Anatomy, Goa Medical College, Bambolim; <sup>3</sup>Associate Professor, Department of Anatomy, Goa Medical College, Bambolim.

## ABSTRACT

**Background:** The clavicle is a modified long bone that lies horizontally across the root of the neck in the human body. The nutrient artery is the primary source of supply to a long bone. It enters the bone through the nutrient foramen which is directed away from the growing end. A nutrient foramen is present in the lateral end of the subclavian groove, running laterally and transmitting the nutrient artery which is derived from the suprascapular artery. The study aimed to find variation in the number, position, location and direction of nutrient foramina in dry human clavicles in the Goan population.

**Material and Methods:** The study was carried out on 70 dry human clavicles in the Department of Anatomy, Goa Medical College using a measuring scale and digital vernier callipers. Hughes formula was used to calculate the foramen index.

**Results:** Nutrient foramen was present in all 70 clavicles. Single nutrient foramen was present in 57.14% clavicles; double foramina in 32.85% clavicles, three foramina were present in 8.57% clavicles and four foramina in 1.42% clavicles. The majority of the foramina (64.81%) were located on the posterior surface. Most of the foramina (94.44%) were positioned in the middle 1/3rd region. The nutrient foramina were directed laterally in all the clavicles. The mean distance of foramen from the sternal end of the clavicle was 70.81 and the mean foraminal index was 51.54.

**Conclusion:** The clavicle is one of the most commonly fractured bones. It is typically fractured in the middle third. Knowledge of the location and position of the nutrient foramen is imperative to orthopaedic surgeons because damage to the nutrient artery might interfere with the healing of the fracture. Proper knowledge and understanding of the morphometric and topographic properties of the nutrient foramina will assist orthopaedic surgeons to preserve the microcirculation while performing surgeries on the clavicle.

**Key Words:** Clavicle, Nutrient foramen, Foraminal index, Fracture

## INTRODUCTION

The clavicle is a modified long bone. It is derived from the Latin word *clavis* meaning a key because it resembles a primitive key or stick<sup>1</sup>. It lies horizontally across the root of the neck<sup>2</sup> in the human body. It consists of a shaft that is gently curved and resembles the italic letter *f* in shape and two ends, acromial or lateral and sternal or medial. The shaft can be divided into lateral one-third and medial two-thirds. It helps to transmit part of the weight of the upper limb to the axial skeleton. A nutrient foramen is present in the lateral end of the subclavian groove, running in a lateral direction transmitting the nutrient artery which is derived from the suprascapular artery.<sup>3</sup> The nutrient artery is the primary source of blood supply to a long bone. It enters the bone obliquely

through the nutrient foramen which is directed away from the growing end following the dictum 'to the elbow I go, from the knee I flee'.<sup>4</sup>

The topographical knowledge of these foramina is useful in fracture treatment and certain operative procedures like internal fixation and bone grafting so that circulation is not compromised by damage to the vessels.

**Aim of the study:** To study the variations in number, position, location and direction of nutrient foramina in dry human clavicles which would help the orthopaedic surgeon in fracture treatment, bone grafting and microsurgical bone transplantation.

### Corresponding Author:

Dr. Siddhesh Prakash Prabhu, Assistant Professor, Department of Anatomy, Goa Medical College, Bambolim.

Email: [siddhugoa@gmail.com](mailto:siddhugoa@gmail.com)

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## MATERIALS AND METHODS

The study was carried out on 70 dry human clavicles ( 41 left and 29 right) of unknown sex in the Department of Anatomy, Goa Medical College, Bambolim after due clearance from the Institutional Ethics Committee. Clavicles that were damaged were excluded from the study. The length of the clavicle was measured with a measuring scale. The bones were observed for number, location, position and direction of nutrient foramina. The distance of the foramen from the sternal end of the clavicle was measured using digital Vernier callipers with an accuracy of 0.01 mm. The foraminal index was calculated using the Hughes formula which states that

$FI = (DNF/TL) \times 100$  where FI = foraminal index; DNF = the distance of foramen from the sternal end of the clavicle and TL = total length of clavicle <sup>5</sup>. Data was collected and analysed morphologically.

**Observations:** Nutrient foramen was observed in all the clavicles studied. The number of foramina in the clavicles, their location and position are summarised in table 1, 2 & 3 respectively. Figure 1 shows the distribution of the nutrient foramina in the clavicles. Figures 2 and 3 show clavicles having two nutrient foramina each. Figure 4 depicts a clavicle having three nutrient foramina.

**Table 1: Number of nutrient foramina**

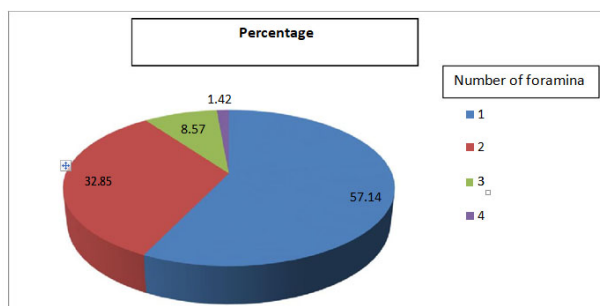
| Number of foramina | Right clavicles(29) | Left clavicles(41) | Total right +left (70 clavicles) |
|--------------------|---------------------|--------------------|----------------------------------|
| 1                  | 18 (62.06%)         | 22 (53.65%)        | 40 (57.14%)                      |
| 2                  | 09 (31.03%)         | 14 (34.14%)        | 23 (32.85%)                      |
| 3                  | 02 (6.89%)          | 04 (9.75%)         | 06 (8.57%)                       |
| 4                  | 00                  | 01 (2.43%)         | 01(1.42%)                        |

**Table 2: Location of foramina**

| Topographic location | Right ( 42 foramina) | Left ( 66 foramina) | Total right +left (108 foramina) |
|----------------------|----------------------|---------------------|----------------------------------|
| Anterior             | 00 (0%)              | 00 (0%)             | 00 (0%)                          |
| Posterior            | 27 (64.28%)          | 43 (65.15%)         | 70 (64.81%)                      |
| Superior             | 02 (4.76%)           | 02 (3.03%)          | 04 (3.70%)                       |
| Inferior             | 13 (30.95%)          | 21 (31.81%)         | 34 (31.48%)                      |

**Table 3: Position of foramen**

| Position of foramina | Right( 42 foramina) | Left( 66 foramina) | Total Right+Left(108 foramina) |
|----------------------|---------------------|--------------------|--------------------------------|
| Medial 1/3           | 04 (9.52%)          | 01 (1.51%)         | 05 (4.62%)                     |
| Middle 1/3           | 38 (90.47%)         | 64 (96.96%)        | 102(94.44%)                    |
| Lateral 1/3          | 00 (0%)             | 01 (1.51%)         | 01(0.92%)                      |



**Figure 1:** Distribution of nutrient foramina in the clavicles.



**Figure 2:** Clavicle showing two nutrient foramina; one on superior and one on posterior surface.



**Figure 3:** Clavicle showing two nutrient foramina on posterior surface.



**Figure 4:** Clavicle showing three nutrient foramina on the posterior surface.

The mean total length of the clavicle, the distance of the nutrient foramen from the sternal end and foraminal index are summarised in Table 4

**Table 4: Distance of foramina from the sternal end and foraminal index**

|  | Right  |       |             | Left   |       |              | Total Right+ Left |       |              |
|--|--------|-------|-------------|--------|-------|--------------|-------------------|-------|--------------|
|  | Mean   | SD    | Range       | Mean   | SD    | Range        | Mean              | SD    | Range        |
| Distance of foramen from sternal end (in mm) | 67.76  | 14.99 | 37.31-92.76 | 72.75  | 12.46 | 43.94-109.34 | 70.81             | 13.65 | 37.31-109.34 |
| Total length of clavicle (mm)                | 135.27 | 10.46 | 104-151     | 138.26 | 9.05  | 118-158      | 137.02            | 9.70  | 104-158      |
| Foraminal index                              | 49.98  | 9.39  | 28.26-63.97 | 52.54  | 8.34  | 31.84-69.2   | 51.54             | 8.81  | 28.26-69.2   |

The nutrient foramina were directed laterally in all the clavicles.

## DISCUSSION

In a study conducted by Murlimanju BV et al. <sup>6</sup> on 52 clavicles, nutrient foramina were seen in 50 clavicles. Single foramen was observed in 38.5%, double in 44.2% and more than 2 foramina in 13.4% of the clavicles. The foramina were positioned in the middle 1/3<sup>rd</sup> region in the majority of the clavicles and more commonly placed on the posterior surface. The foramina were directed towards the acromial end in their study. They observed that the average distance of the foramen from the sternal end was 64.4 mm and the mean foraminal index was 44.72 in their study.

Soumya G et al. <sup>7</sup> in their study conducted on 110 clavicles observed that nutrient foramina were present in 93.6% of the clavicles and absent in 6.4% of the clavicles. They found that the foramen was single in 72.7%, double in 16.4%, and more than 2 foramina in 4.5% of the clavicles. They noticed that the nutrient foramina were present mostly on the posterior surface as compared to the inferior surface of the middle 1/3<sup>rd</sup> of the clavicle. They found that the foramina were directed towards the acromial end in 95.1% of the clavicles and directed medially in 4.8%. They calculated the mean foraminal index as 47.31% according to Hughes formula. The mean distance of the foramen from the sternal end was about 67.65 mm in their study.

Rai R et al. <sup>8</sup> in their study on 40 clavicles noted that a single foramen was present in 42.5%, double foramina in 52.5% and more than two foramina in 5% of the clavicles. They observed the presence of foramen at the medial 1/3<sup>rd</sup> region in 19.2%, at the middle 1/3<sup>rd</sup> portion in 67.3% and the lateral 1/3<sup>rd</sup> region in 13.5% of the clavicles. They found that 35.4% foramina were situated on the inferior surface and 64.6% foramina on the posterior surface of the clavicles. They deduced that the average distance of the foramen from the sternal end was 6.76 cm and the mean foraminal index was 48.01. All the foramina in their study were found to be directed away from the growing end

Joshi P and Mathur S <sup>9</sup> in their study on 50 clavicles found nutrient foramen was absent in 6% of clavicles. They observed single foramen in 68% and double foramina in 26% of the clavicles. The majority of the foramina were on the posterior surface (76%) of the medial 2/3<sup>rd</sup> of the clavicles. They calculated the mean foraminal index as 47.76%. The mean distance of foramen from the proximal end in their study was 58.47mm

A study by Tanna N and Tanna V <sup>10</sup> on 50 clavicles found the presence of nutrient foramen on all the clavicles. They noted that a single foramen was present in 42%, two foramina in 52% and three foramina in 6% of the clavicles. They observed that 36.6% of the foramina were on the inferior surface and 63.4% were on the posterior surface of the clavicles.

They noticed that 18.3% of the foramina were located at the medial 1/3rd region, 72% at the middle 1/3rd region, and 9.8% at the lateral 1/3rd region. They calculated the mean foraminal index to be 49.01. The average distance of foramen from the sternal end was 6.98 in their study and all the foramina were directed away from the growing end.

Lal N et al.<sup>11</sup> in their study on 50 clavicles observed the presence of nutrient foramen in 47 clavicles (94%). They found the presence of a single foramen in 68% and the presence of double foramina in 26% of the bones. They observed that majority of foramina were present in the middle third and on the posterior surface of the bones. All the foramina observed in their study were directed towards the acromial end.

Rao KRS and Janaki V<sup>12</sup> conducted a study on 58 clavicles and found the presence of neurovascular foramina in all clavicles. They observed a single foramen in 48.3%, double in 32.7%, three foramina in 8.3% and more than three foramina in 10.3% of the clavicles. In 89% of the clavicles, the foramen was noted in the medial 2/3rd of the bone and 11%, the foramen was seen in the lateral 1/3rd of the bone. In 50% of the clavicles, the foramen was present on the posterior surface whereas, in 40.3% of clavicles, the foramen was seen on the inferior surface. In 6.9% of the bones, the foramen was present at its superior surface and in only 2.7% the nutrient foramen was present on the anterior surface. They observed that the average distance of the foramen from the sternal end was 6.23cm.

A study by Sinha S et al.<sup>13</sup> on 50 clavicles found the presence of nutrient foramen in all the clavicles. They noted the presence of one foramen in 70%, two foramina in 24% and three foramina in 6% of the clavicles. They observed that nutrient foramen was predominantly positioned on the posterior surface (55.88%) and located mostly in the middle one third (70.58%) of the clavicles. They found that the average distance of the nutrient foramina from the sternal end was 69.63 mm. They calculated the mean foramen index as 52.25. All the nutrient foramina were directed away from the sternal end in their study.

Kumar D et al.<sup>14</sup> in their study on 102 clavicles found the presence of nutrient foramina in 92 clavicles out of which there was single foramen in 75 clavicles, double foramina in 15 clavicles, and three foramina in 2 clavicles. It was observed in their study that the majority of the foramina were present in the medial 2/3rd of the bones and on the posterior surface of the bones. They noticed that all the nutrient foramina were directed towards the acromial end.

Dr Saha PK et al.<sup>15</sup> found in their study on 54 clavicles that nutrient foramen was present in all the clavicles. They observed that a single foramen was present in 53.70%, double in 40.74% and more than two in 5.56% of the clavicles. They noted that the majority of foramina were located in the mid-

dle third (74.39%) and positioned on the posterior surface (59.76 %). They observed that most of the nutrient foramina were directed towards the acromial end. They calculated the mean foraminal index as 47.65.

Hussain A et al.<sup>16</sup> in their study on 60 clavicles observed nutrient foramen in all the clavicles. They found the presence of a single foramen in 36.6%, double foramina in 50%, triple foramina in 10% and quadruple foramina in 3.3% of the clavicles. They noticed that out of the 108 foramina, 61.1% were situated on the posterior surface of the clavicle, 27% were present on the inferior surface and the remaining 11.1% were on the anterior surface. They also observed that 90% of foramina were located on middle 1/3 and 10% on lateral 1/3. They observed in their study that 98.3% of the nutrient foramina were directed towards the acromial end while the remaining 1.7 % towards the sternal end. The mean distance of the nutrient foramina from the sternal end was 7.46 cm.<sup>21</sup>

In a study by Suma MP et al.<sup>17</sup> total number of clavicles studied was 50 out of which 48 showed the presence of nutrient foramen. Single foramen was present in 39 clavicles, double foramina in 6 clavicles and more than two foramina in 3 cases. 85.5% of the foramina were positioned in the middle 1/3rd, 6.5% in the medial 1/3rd and 8% in the lateral 1/3rd of the clavicles. 62.9% foramina were located on the inferior surface, 33.8% on the posterior surface and 3.22% on the anterior surface of the clavicles. They noticed that the nutrient foramina were directed away from the growing end.

Sahu S and Meher D<sup>18</sup> in their study on 53 clavicles concluded that most of the foramina were present in the middle third region (71.4%) and also on the posterior surface (63.10%) of the clavicles which they studied. They found that all the clavicles in their study had the nutrient foramina directed away from the sternal end. The mean foraminal index was 52.06 in their study and the average distance of the foramen from the sternal end was observed to be 65.8 mm.

A study by Leschinger T et al.<sup>19</sup> on 317 macerated clavicles found a dominant foramen in 94.67% of the bones which was situated in the middle third in 95.7% of the clavicles. They observed that the average distance of the foramen from the sternoclavicular joint surface was 7.9 cm and the mean foraminal index was 53.2%

Dr Rekha and Dr Simriti<sup>20</sup> observed in their study that nutrient foramen was directed towards the acromial end in 90.47% and towards the sternal end in 4.7% of the clavicles.

In the present study, nutrient foramen was present in all the 70 clavicles studied. A single foramen was observed in 40 cases (57.14%), double in 23 cases (32.85%), three foramina in 6 cases ( 8.57%) and four foramina in 1 clavicle (1.42%). Table 5 shows the comparison of nutrient foramina of the present study and other studies



**Table 5: Comparison of the number of nutrient foramina of the present study and other studies**

| No of foramina | Dr Saha PK et al (54 clavicles) | Sahu S and Meher D (53 clavicles) | Joshi P and Mathur S (50 clavicles) | Tanna N and Tanna V (50 clavicles) | Lal N et al (50 clavicles) | Rai R et al (40 clavicles) | Sinha S et al (50 clavicles) | Present Study (70 clavicles) |
|----------------|---------------------------------|-----------------------------------|-------------------------------------|------------------------------------|----------------------------|----------------------------|------------------------------|------------------------------|
| Absent         | -----                           | -----                             | 6%                                  | -----                              | 6%                         | -----                      | -----                        | -----                        |
| 1              | 53.70%                          | 43.38%                            | 68%                                 | 42%                                | 68%                        | 42.5%                      | 70%                          | 57.14%                       |
| 2              | 40.74%                          | 50.93%                            | 26%                                 | 52%                                | 26%                        | 52.5%                      | 24%                          | 32.85%                       |
| 3              | 5.56%                           | 5.65%                             | -----                               | 6%                                 | -----                      | 5%                         | 6%                           | 8.57%                        |
| 4              | -----                           | -----                             | -----                               | -----                              | -----                      | -----                      | -----                        | 1.42%                        |

In the present study, we observed that 64.81% of foramina were situated on the posterior surface, 31.48% on the inferior surface and 3.70% on the superior surface. The majority of foramen was on the posterior surface similar to the study done by Rai R et al. <sup>8</sup> Joshi P and Mathur S. <sup>9</sup> Tanna N and Tanna V, <sup>10</sup> Sinha S et al. <sup>13</sup> Dr Saha PK et al. <sup>15</sup> Hussain A et al. <sup>16</sup> Sahu S and Meher D <sup>18</sup>.

In the present study, 94.44% of the foramina were positioned in the middle 1/3<sup>rd</sup> region, 4.62% in the medial 1/3<sup>rd</sup> and 0.92% in the lateral 1/3<sup>rd</sup> region of the clavicle. These findings are similar to those of the studies mentioned in table 6.

**Table 6: Comparison of the position of nutrient foramina of the present study and other studies**

| Position of foramen       | Sahu S and Meher D | Tanna N and Tanna V | Rai R et al | Sinha S et al | Dr Saha PK et al | Hussain A et al | Present Study |
|---------------------------|--------------------|---------------------|-------------|---------------|------------------|-----------------|---------------|
| Medial 1/3 <sup>rd</sup>  | 19.04%             | 18.3%               | 15.4%       | 10.29%        | 17.07%           | -----           | 4.62%         |
| Middle 1/3 <sup>rd</sup>  | 71.42%             | 72%                 | 73.8%       | 70.58%        | 74.39%           | 90%             | 94.44%        |
| Lateral 1/3 <sup>rd</sup> | 9.52%              | 9.8%                | 10.8%       | 19.11%        | 8.53%            | 10%             | 0.92%         |

In the present study, all the foramina were directed towards the acromial end which is in agreement with most of the textbook descriptions and with the studies done by Suma MP et al. <sup>17</sup> Murlimanju BV et al. <sup>6</sup> Sinha S et al. <sup>13</sup> Rai R et al. <sup>8</sup> Sahu S and Meher D <sup>18</sup> and Lal N et al. <sup>11</sup> The average

distance of foramina from the sternal end was 70.81 MMS and the foraminal index was 51.54. Table 7 shows the comparison between the foraminal index of the present study and other studies

**Table 7: Comparison of the mean foraminal index of the present study and other studies**

|                      | Sowmiya G et al. | Sahu S and Meher D | Joshi P and Mathur S | Tanna N and Tanna V | Rai R et al. | Sinha S et al. | Dr Saha PK et al. | Murli-manju BV et al. | Hussain A et al. | Present Study |
|----------------------|------------------|--------------------|----------------------|---------------------|--------------|----------------|-------------------|-----------------------|------------------|---------------|
| Mean foraminal index | 47.31            | 52.06              | 49.76                | 49.01               | 48.01        | 52.25          | 47.65             | 44.72                 | 51.41            | 51.54         |

## CONCLUSION

The clavicle is one of the most commonly fractured bones. The junction of the middle third and lateral thirds of the bone is its weakest part. It is typically fractured in the middle third. Fracture is rare in the medial and lateral third. We observed in our study that the nutrient foramen was located mostly in the middle third region of the bone on the posterior surface. A fracture at this site could damage the nutrient artery leading to the compromised blood supply to the bone. This in turn could delay the healing of the fracture as it is dependent on blood supply for nutrition.

Knowledge of the location and position of the nutrient foramen is imperative to surgeons while reducing fractures of the bone because of increased chances of damaging the nutrient vessel during operative procedures. Also, intact nutrient vascular supply is important in bone grafting for healing. A proper understanding of the morphometric and topographic properties of the nutrient foramina will help orthopaedic surgeons to preserve microcirculation while performing surgeries on the clavicle.

**Conflicts of interest:** The authors have none to declare.

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