Review Article
https://doi.org/10.5115/acb.23.220
eISSN 2093-3673
Anatomy & Cell Biology acb

A comprehensive review of the mental spine

Ross Champagne[1], Rithvik Vutukuri[2], Chung Yoh Kim[1], R. Shane Tubbs[1,3,4,5,6,7,8], Joe Iwanaga[1,3,4,9,10,11]

[1]Department of Neurosurgery, Tulane Center for Clinical Neurosciences, Tulane University School of Medicine, New Orleans, LA, [2]Tulane University School of Medicine, New Orleans, LA, [3]Department of Neurology, Tulane Center for Clinical Neurosciences, Tulane University School of Medicine, New Orleans, LA, [4]Department of Structural & Cellular Biology, Tulane University School of Medicine, New Orleans, LA, USA, [5]Department of Anatomical Sciences, St. George's University, St. George's, Grenada, [6]Department of Surgery, Tulane University School of Medicine, New Orleans, LA, [7]Department of Neurosurgery and Ochsner Neuroscience Institute, Ochsner Health System, New Orleans, LA, USA, [8]University of Queensland, Brisbane, Australia, [9]Department of Oral and Maxillofacial Anatomy, Graduate School of Medical and Dental Sciences, Tokyo Medical and Dental University, Tokyo, [10]Dental and Oral Medical Center, Kurume University School of Medicine, Kurume, [11]Division of Gross and Clinical Anatomy, Department of Anatomy, Kurume University School of Medicine, Kurume, Japan

Abstract: Clinical case reports and research regarding the mental spines and their associated structures create a detailed picture of the floor of the mouth for assessment during clinical treatment. This compilation of information covers the mental spines, the attached geniohyoid and genioglossus muscles, the lingual foramina, and the veins and arteries of the jaw and floor of the mouth. It is important to consider the variations in the mental spines for oral and maxillofacial treatment involving the mandible. Differences in anatomy of the mental spine, including their number, location, and size, can impact diagnosis and treatment approaches.

Key words: Cadaver, Oral cavity, Mandible, Osteology, Anatomy

Received August 27, 2023; 1st Revised September 30, 2023; 2nd Revised October 12, 2023; Accepted October 17, 2023

Introduction

The mental spines (genial tubercles) and the lingual foramina are part of the mandibular symphysis, located along the anterior mandible's midline and lower lingual position [1, 2]. Generally, the human mandible consists of four mental spines split into pairs, which serve as muscle attachment sites. The superior pair attaches to the genioglossus muscle, while the inferior pair attaches to the geniohyoid muscle [1].

While it has been widely accepted that the standard mandible features four mental spines, recent research has revealed that one or two distinct mental spines are possible but may also be more common than the presence of four (Fig. 1) [3]. Variations in the anatomy of the mental spines contribute to changes in the lingual foramina and the attachment of muscles to the anterior mandible [1, 3-6]. These changes help determine how the arteries that supply blood to the submandibular region enter the mandible through the lingual foramina [7-19].

The mental spines are generally of small size but can develop into larger prominences due to calcification of the geniohyoid and genioglossus muscle tendons and severe atrophy of the mandible. This condition is referred to as the "elongated mental spine" (Fig. 2) [2, 20]. The more eminent tubercles become prone to fracturing spontaneously or due to ill-fitting dentures [9, 21-23]. To begin treatment, several radiographic techniques in differing combinations are used in oral and maxillofacial diagnoses to acquire clear images of affected regions [21, 24-31]. Next, clinical treatment of fractured mental spines is accomplished through conservative or surgical means, typically leading to successful recovery of the damaged mandible and attached muscles [31].

Corresponding author:
Joe Iwanaga
Department of Neurosurgery, Tulane Center for Clinical Neurosciences, Tulane University School of Medicine, New Orleans, LA 70112, USA
E-mail: iwanagajoeca@gmail.com

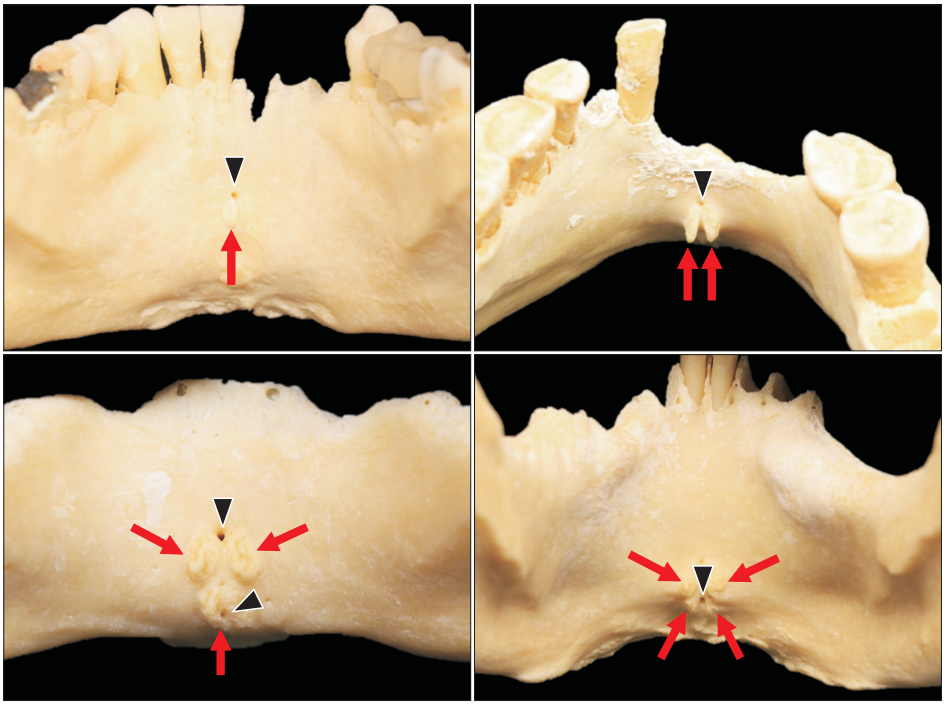

Fig. 1. Various number of mental spines (arrows). Note that the median lingual foramina are shown (arrowheads).

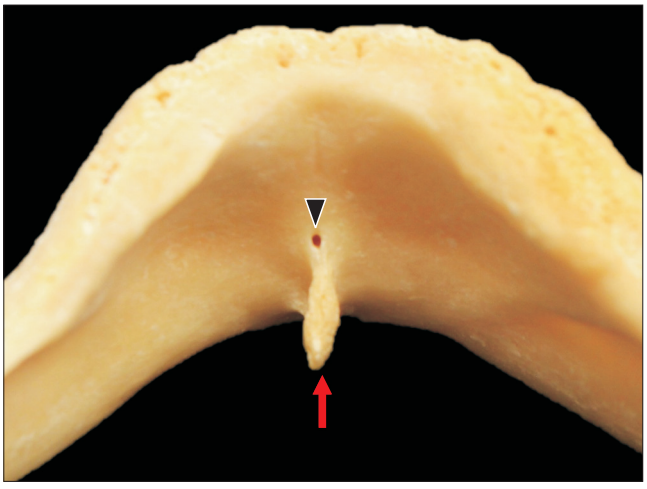

Fig. 2. An elongated mental spine (arrow) and median lingual foramen (arrowhead).

Review

Terminology

The mental spines of the mandible are also known as genial spines, genial tubercles, genial apophysis, and spinae mentalis [32]. The terms tubercle, spine, and apophysis describe bone projections that remain attached to the larger bone structure they originate from. In this case, the larger bone is the anterior mandible [33]. These terms are typically used interchangeably, but their situational use varies depending on the size of the protuberance [2]. "Mental" originates from the Latin word mentum, and "genial" derives from the Greek word genion, both referring to the chin [33].

Anatomy

The superior and inferior pairs of mental spines are typically accompanied by lingual foramina in varying numbers, forms, and positions [1]. The lingual foramina are entrances to canals that run from the cortical bone surface to the intraosseous region on the lingual surface of the mandible [4, 6]. These foramina can be categorized by their location in relation to the mental spines [1, 3]. Supra-spinosum describes when the foramen is above the mental spines, inter-spinosum refers to when the foramen is between or at the same level as the superior and inferior mental spines, and infra-spinosum pertains to when the foramen is below the inferior mental spines [1, 3, 5, 6].

The sublingual artery branches into several vessels to reach different parts of the floor of the mouth. Its branches enter the lingual foramina near the mental spines as an anastomosis of vessels from the left and right lingual arteries [15].

The submental artery, the largest cervical branch of the facial artery, follows various paths. Its branches often perforate the mylohyoid muscle to enter the median lingual foramina near the mental spine or the lateral lingual foramina

into the mandible, where it can anastomose with branches of the sublingual artery and eventually reach the skin of the chin [34].

Radiology

The mental spines are usually shown as a prominence of the lingual cortical plate at the inferior mandible on cone-beam computed tomography (CBCT) (Fig. 3). Conventional CT and CBCT scans can confirm a diagnosis and determine the extent of the fracture damage [21, 31]. Lateral oblique and posteroanterior X-rays can be used in conjunction with other radiographs for a clinician to investigate the affected area [31].

Anatomical variation

Most anatomical textbooks describe the mental spines as four protuberances on the internal surface of the mandibular symphysis, arranged in two pairs placed one above the other [3, 35-41]. However, it has been discovered that human mandibles can have between one and four spines with varying positionings [3, 40, 41].

Studies have found that the most common mental spine anatomy consists of two superior spines [3, 40-42]. These spines form due to the consistent use of attached muscles pulling on the bone [3]. The genioglossus muscle attaches to the mandible via the superior pair of mental spines [2, 3]. The genioglossus muscle runs along the entire ventral surface of the tongue, so when the muscle is contracted, the tongue is drawn forward and out of the mouth [3]. The constant protrusion and depression of the tongue during deglutition leads to the greater prominence of the superior mental spines [3]. The geniohyoid muscle, attached to the mandible via the inferior mental spines (Fig. 4), runs along the anterior surface of the hyoid bone to either draw it forward when the mandible is fixed or depress the mandible when the hyoid is fixed [3]. The less prominent inferior mental spines result from this muscle's weaker contraction and pulling force [3].

When the geniohyoid muscle originates from a linear attachment on the mandibular symphysis, a median vertical spine can replace the two inferior mental spines [43]. However, a rough impression may result when the muscle's origin is weakly attached [3].

Rarely the genioglossus and geniohyoid muscles originate from the same point of attachment on the mandible, causing the formation of a single large eminence instead of superior and inferior mental spines [39]. This single prominent eminence may sometimes form, and in some cases, no spine, ridge, or notable prominence is possible [3].

These morphological patterns of the mental spine have been investigated in some studies [3, 40, 41]. Singh et al. [3] examined 1,200 dry adult mandibles and classified them into five morphological groups. Araby et al. [40] adopted same classification for CBCT of 155 subjects. However, Hu et al. [41] investigated superior and inferior mental spines of 102 mandibles respectively and made seven groups in total for mental spine classification. The frequency of these different morphologies in the studies are summarized in the Table 1.

Clinical relevance

The mental spines play an important role in the success or failure of a patient's ability to support dentures. For patients with resorbed mandibles, the mental spines serve as a solid foundation for withstanding the vertical forces of dentures since the attachment of the genioglossus muscles allows the spines to resist resorption [44]. However, the mucosa cover-

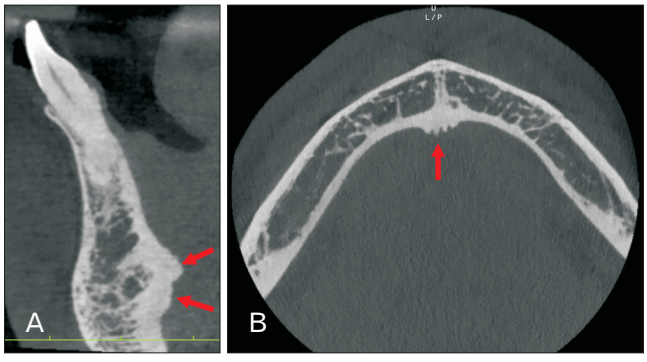

Fig. 3. (A) Midsagittal and (B) axial cone-beam computed tomography of the mental spines (arrows).

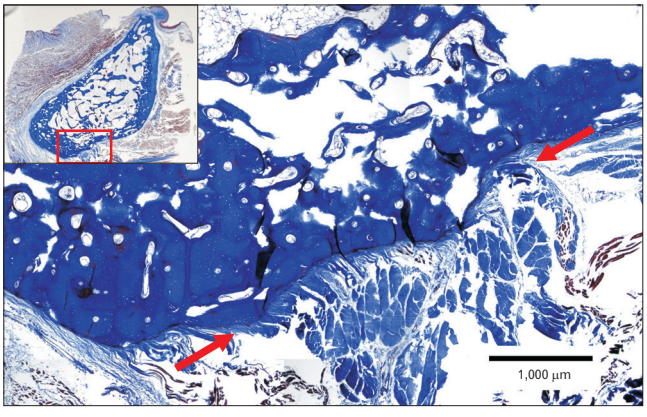

Fig. 4. Masson's trichrome staining of the para-midsagittal mandible. Note that the tendon of the geniohyoid muscle (between arrows) attaches to the mental spines.

https://doi.org/10.5115/acb.23.220

Table 1. Variation in mental spine morphology

Type	Singh et al. [3]	Araby et al. [40]
Absent	22 (1.83)	10 (6.4)
Two pairs of spines placed one above the other	231 (19.25)	22 (14.2)
Two superior spines with median vertical ridge below	562 (46.83)	35 (22.6)
Two superior spines with rough impression below	280 (23.33)	57 (36.8)
Single prominence	105 (8.75)	31 (20)
Total	1,200 (100)	155 (100)

Type	Hu et al. [41]	
	Superior mental spine	Inferior mental spine
Sharp separation	54.3	5.7
Dull separation	10.5	2.9
Sharp fusion	7.6	31.4
Dull fusion	3.8	37.1
Triple separation	0.9	0.0
Sharp fusion (superior mental spine and inferior mental spine)	18.1	
Dull fusion (superior mental spine and inferior mental spine)	4.8	
Total	107 (100)	

Values are presented as number (%) or percentage only. Percentages may not add to 100 due to rounding.

ing the protuberances tends to restrict the tubercles' ability to be primary stress-bearing regions [44]. If the skin has been grafted over the mental spines and the tissue overlying the muscle attachment zones becomes keratinized, this can serve as a primary support area [44].

Severe mandibular atrophy, particularly around the alveolar ridge, can leave the mental spines as hard, prominent projections, leading to fracture of the tubercles, either spontaneously or due to an ill-fitting denture [9, 21-23]. The pressure from lower dentures causes micro-fractures in the tubercles. Following this, the contraction of attached muscles leads to their spontaneous separation from the mandible [31, 45]. Clinicians have two approaches for treating fractured mental spines. The first is a conservative method, which involves pain relief and allowing the body to heal naturally. The second approach involves surgical removal of the fractured tubercle, followed by replacement or repositioning of the associated muscles [31, 46].

Conclusion

The mental spines' role as attachment sites for the genioglossus and geniohyoid muscles underscores their significant implications for the broader oral and facial structure. Careful attention to these mental spines and associated muscles, arteries, and bone is crucial to delivering effective and efficient care. Ongoing clinical studies enhance the methods, speed, and effectiveness of diagnosis, treatment, and recovery.

ORCID

Ross Champagne: https://orcid.org/0009-0008-1382-7839
Rithvik Vutukuri: https://orcid.org/0000-0003-2498-4377
Chung Yoh Kim: https://orcid.org/0000-0001-8074-076X
R. Shane Tubbs: https://orcid.org/0000-0003-1317-1047
Joe Iwanaga: https://orcid.org/0000-0002-8502-7952

Author Contributions

Conceptualization: RST, JI. Data acquisition: RST, JI. Data analysis or interpretation: RC. Drafting of the manuscript: RC. Critical revision of the manuscript: RV, RST, JI. Approval of the final version of the manuscript: all authors.

Conflicts of Interest

No potential conflict of interest relevant to this article was reported.

Funding

None.

Acknowledgements

The authors sincerely thank those who donated their bodies to science so that anatomical research could be performed. Results from such research can potentially increase mankind's overall knowledge that can then improve patient care. Therefore, these donors and their families deserve our highest gratitude [47].

References

1. von Arx T, Lozanoff S. Clinical oral anatomy: a comprehensive review for dental practitioners and researchers. Springer International Publishing; 2017.
2. Wong TL, Iwanaga J, Anand MK, Tubbs RS. An elongated mental spine: case report. Natl J Clin Anat 2019;8:130-1.

3. Singh V, Anand MK, Dinesh K. Variations in the pattern of mental spines and spinous mental foramina in dry adult human mandibles. Surg Radiol Anat 2000;22:169-73.
4. He P, Truong MK, Adeeb N, Tubbs RS, Iwanaga J. Clinical anatomy and surgical significance of the lingual foramina and their canals. Clin Anat 2017;30:194-204.
5. Sanomiya Ikuta CR, Paes da Silva Ramos Fernandes LM, Poleti ML, Alvares Capelozza AL, Fischer Rubira-Bullen IR. Anatomical study of the posterior mandible: lateral lingual foramina in cone beam computed tomography. Implant Dent 2016;25:247-51.
6. Tagaya A, Matsuda Y, Nakajima K, Seki K, Okano T. Assessment of the blood supply to the lingual surface of the mandible for reduction of bleeding during implant surgery. Clin Oral Implants Res 2009;20:351-5.
7. Bavitz JB, Harn SD, Homze EJ. Arterial supply to the floor of the mouth and lingual gingiva. Oral Surg Oral Med Oral Pathol 1994;77:232-5.
8. Beer JI, Sieber DA, Scheuer JF 3rd, Greco TM. Three-dimensional facial anatomy: structure and function as it relates to injectable neuromodulators and soft tissue fillers. Plast Reconstr Surg Glob Open 2016;4(12 Suppl):e1175.
9. Hayakawa I. Principles and practices of complete dentures: creating the mental image of a denture. Quintessence Pub. Co.; 1999.
10. Hofschneider U, Tepper G, Gahleitner A, Ulm C. Assessment of the blood supply to the mental region for reduction of bleeding complications during implant surgery in the interforaminal region. Int J Oral Maxillofac Implants 1999;14:379-83.
11. Hollinshead WH. Textbook of anatomy. 3rd ed. Harper & Row; 1974.
12. Kalpidis CD, Setayesh RM. Hemorrhaging associated with endosseous implant placement in the anterior mandible: a review of the literature. J Periodontol 2004;75:631-45.
13. Laboda G. Life-threatening hemorrhage after placement of an endosseous implant: report of case. J Am Dent Assoc 1990;121:599-600.
14. Lee HJ, Won SY, O J, Hu KS, Mun SY, Yang HM, Kim HJ. The facial artery: a comprehensive anatomical review. Clin Anat 2018;31:99-108.
15. McDonnell D, Reza Nouri M, Todd ME. The mandibular lingual foramen: a consistent arterial foramen in the middle of the mandible. J Anat 1994;184(Pt 2):363-9.
16. Meegalla N, Sood G, Nessel TA, Downs BW. Anatomy, head and neck: facial arteries. StatPearls Publishing; 2022.
17. Seki S, Sumida K, Yamashita K, Baba O, Kitamura S. Gross anatomical classification of the courses of the human lingual artery. Surg Radiol Anat 2017;39:195-203.
18. Sicher H, Brul ELD. Sicher's oral anatomy. 7th ed. Mosby; 1980.
19. Williams PL, Warwick R, Dyson M, Bannister LH. Gray's anatomy. 37th ed. Churchill Livingstone; 1989.
20. van Leeuwen AC, van der Meij EH, de Visscher JG. Fracture of the genial tubercles of the mandible: case report and review of the literature. J Oral Maxillofac Surg 2014;72:1994.e1-6.
21. Gallego L, Junquera L, Villarreal P, de Vicente JC. Spontaneous fracture of the mandibular genial tubercles. A case report. Med Oral Patol Oral Cir Bucal 2007;12:E599-601.
22. Păuna MR, Babiuc I, Farcaşiu AT. Prosthodontic management of an extreme atrophy of the mandible correlated with a prominent genial tubercle - a clinical report. Rom J Morphol Embryol 2015;56(2 Suppl):867-70.
23. Shohat I, Shoshani Y, Taicher S. Fracture of the genial tubercles associated with a mandibular denture: a clinical report. J Prosthet Dent 2003;89:232-3.
24. Choi YJ, Jun SH, Song YD, Chang MW, Kwon JJ. CT scanning and dental implant. In: Subburaj K, editor. CT Scanning - Techniques and Applications. InTech; 2011. p.229-50.
25. Cosson J. Interpreting an orthopantomogram. Aust J Gen Pract 2020;49:550-5.
26. Easley J. A new look at dental radiology. Paper presented at: Proceedings of the 48th Annual Convention of the American Association of Equine Practitioners Annual Convention; 2002 Dec 4-8; Orlando (FL), USA. p. 412-20.
27. Gupta A, Devi P, Srivastava R, Jyoti B. Intra oral periapical radiography - basics yet intrigue: a review. Bangladesh J Dent Res Educ 2014;4:83-7.
28. Kim JH, Aoki EM, Cortes AR, Abdala-Júnior R, Asaumi J, Arita ES. Comparison of the diagnostic performance of panoramic and occlusal radiographs in detecting submandibular sialoliths. Imaging Sci Dent 2016;46:87-92.
29. Schüler IM, Hennig CL, Buschek R, Scherbaum R, Jacobs C, Scheithauer M, Mentzel HJ. Radiation exposure and frequency of dental, bitewing and occlusal radiographs in children and adolescents. J Pers Med 2023;13:692.
30. Sukovic P. Cone beam computed tomography in craniofacial imaging. Orthod Craniofac Res 2003;6 Suppl 1:31-6; discussion 179-82.
31. Wan C, Bowe C, Madhavarajan S. Spontaneous fracture of the genial tubercles of the mandible: a case report and review of the literature. Gerodontology 2017;34:493-7.
32. Selvamuthukumar SC, Aswath N, Karthika B. An incidental finding of enlarged genial tubercles in a case of oral carcinoma. J Indian Acad Oral Med Radiol 2010;22:99-101.
33. Dorland WAN. The American illustrated medical dictionary. 2nd ed. Saunders; 1901.
34. Katsumi Y, Tanaka R, Hayashi T, Koga T, Takagi R, Ohshima H. Variation in arterial supply to the floor of the mouth and assessment of relative hemorrhage risk in implant surgery. Clin Oral Implants Res 2013;24:434-40.
35. Carter RB, Keen EN. The intramandibular course of the inferior alveolar nerve. J Anat 1971;108(Pt 3):433-40.
36. Romanes GJ. Cunningham's manual of practical anatomy. 15th ed. Oxford University Press; 1986.
37. Last RJ, McMinn RMH. Last's anatomy, regional and applied. 8th ed. Churchill Livingstone; 1990.
38. Morris H, Anson BJ. Morris' human anatomy: a complete systematic treatise. 12th ed. McGraw-Hill Book Company; 1966.
39. Williams PL. Gray's anatomy. 38th ed. Churchill Livingstone;

https://doi.org/10.5115/acb.23.220

1995.
40. Araby YA, Alhirabi AA, Santawy AH. Genial tubercles: morphological study of the controversial anatomical landmark using cone beam computed tomography. World J Radiol 2019;11:94-101.
41. Hu KS, Koh KS, Han SH, Shin KJ, Kim HJ. Sex determination using nonmetric characteristics of the mandible in Koreans. J Forensic Sci 2006;51:1376-82.
42. Oda LS, Iyomasa MM, Watanabe IS. Morphologic analysis of the "spina mentalis" in adult mandibles of Brazilian whites and negroes. Rev Bras Pesqui Med Biol 1977;10:357-60.
43. Frazer JES. Frazer's anatomy of the human skeleton. 6th ed. J. & A. Churchill; 1965.
44. Jacobson TE, Krol AJ. A contemporary review of the factors involved in complete dentures. Part III: support. J Prosthet Dent 1983;49:306-13.
45. Yassutaka Faria Yaedú R, Regina Fisher Rubira-Bullen I, Sant'Ana E. Spontaneous fracture of genial tubercles: case report. Quintessence Int 2006;37:737-9.
46. Ferreira Barbosa DA, Marinho Bezerra TM, Barros Silva PG, Menezes Pimenta AV, Kurita LM, Gurgel Costa FW. Clinical, imaging, and therapeutic aspects of genial tubercle fractures: a systematic review. J Oral Maxillofac Surg 2019;77:1674.e1-13.
47. Iwanaga J, Singh V, Ohtsuka A, Hwang Y, Kim HJ, Moryś J, Ravi KS, Ribatti D, Trainor PA, Sañudo JR, Apaydin N, Şengül G, Albertine KH, Walocha JA, Loukas M, Duparc F, Paulsen F, Del Sol M, Adds P, Hegazy A, Tubbs RS. Acknowledging the use of human cadaveric tissues in research papers: recommendations from anatomical journal editors. Clin Anat 2021;34:2-4.