Endosseous Arteries in the Anterior Mandible: Literature Review

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Purpose: *The purpose of this literature review was to investigate the topography of endosseous blood vessels supplying the anterior mandible to prevent complications both during and after oral surgical procedures.* ***Material and Methods:*** *A comprehensive literature search of MEDLINE-PubMed was performed independently for articles describing the anatomical findings of endosseous blood vessels in the anterior part of the mandible. From about 31 related studies, 14 papers were selected based on specific selection criteria. These studies were related to radiologic findings and cadaver studies.* ***Results:*** *There is significant debate concerning the blood vessels supplying the anterior part of the mandible. Hence, in the literature reviewed, no clear consensus was established. There are no reports of severe endosseous bleeding from the mandible during surgical procedures in the symphysis. Based on computed tomographic images, some papers presented an exact intraosseous path of the canals, as well as frequent blood vessel anastomosis in this region. Dissection studies confirmed the presence of sublingual blood vessels penetrating into the bone.* ***Conclusions:*** *The potential risk of bleeding upon perforation of vessels within the bone needs to be evaluated to avoid such complications. The management of intraoperative surgical problems is of significance.* Int J Oral Maxillofac Implants 2012;27:90–94

Key words: *anterior mandible, complications, lingual artery*

The blood supply of the anterior mandible is an issue of significant clinical interest, especially in the treatment of edentulous patients with implants and also as a donor site for bone grafting techniques. The lingual side of the parasymphyseal region of the mandible is a highly vascular area. It has a rich blood supply that lies very close to the interforaminal lingual cortical plate.

The blood supply to this area of the mandible consists of three important arteries: the inferior alveolar artery (and its branch, the mylohyoid artery); the facial artery (and its branch, the submental artery); and the lingual artery (and its branch, the sublingual artery). The artery most commonly implicated or affected in surgical complications is the sublingual artery, and these complications may have significant life-threatening consequences. Anatomical considerations in the anterior part of the mandible are a very important aspect of implant surgery.[1]

The lingual and facial arteries are branches of the external carotid artery. The branches of the lingual artery are the suprahyoid, dorsal lingual, sublingual, and deep lingual. The sublingual artery branches supply the sublingual salivary gland, the mylohyoid and surrounding muscles, and the mucous membranes and gingiva of the mandibular teeth. The sublingual artery is the main nutrient vessel to the floor of the mouth. This artery also has some small alveolar branches that supply the anterior lingual cortical plate.

The submental artery branches from the facial artery at the outer surface of the submandibular gland, moves toward the inferior border of the mandible, and reaches the submental region after passing between the mylohyoid and digastric muscles. The sublingual and submental arteries may be in close association with each other.[1,2]

Many case reports have described surgical complications, such as severe bleeding, both during and after implant placement.[3–17] Although these surgical complications are associated with perforation of the blood vessels in the submandibular area of the mouth floor, there is little literature that discusses the anatomical characteristics and the possible complications arising

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Table 1 Blood Vessel Distribution in the Anterior Mandible Based on Cadaver Studies

Author	Year	Finding
Ennis[30]	1937	Inferior alveolar artery passed through the lingual foramen for anastomosis with the lingual artery
Suzuki and Sakai[25]	1957	Sublingual artery
McDonnell et al[21]	1993	Sublingual artery
Bavitz et al[29]	1994	Submental artery was most often responsible for blood supply; in 53% of cases the sublingual artery was small, missing, and/or insignificant
Hofschneider et al[23]	1999	Sublingual artery
Mardinger et al[31]	2007	Sublingual artery
Loukas et al[20]	2008	Sublingual artery
Vandewalle et al[26]	2006	Sublingual artery and sublingual nerve
Liang et al[27]	2005	Lingual nerve and artery based on magnetic resonance imaging of 10 mandibles (8 examined histologically)
Przystańska and Bruska[32]	2010	Sublingual artery

from the presence of an endosseal blood vessel perforation during oral surgical procedures in this area.[18,19] Kalpidis and Setayesh[2] reviewed case reports of hemorrhage associated with the anterior mandible and recommended that insertion of unnecessarily long implants in the canine region should be avoided.

Therefore, the aim of this study was to analyze the literature presenting the anatomical characteristics associated with the presence of large blood vessels within the bony structure of the symphysis.

MATERIALS AND METHODS

The present literature review sought to investigate the literature regarding the topography of endosseous blood vessels supplying the anterior mandible to prevent complications, both during and after oral surgical procedures.

Search Protocol (Data Source and Search Strategy)

The databases of the US National Library of Medicine, Bethesda, Maryland, (MEDLINE-PubMed) were used to search for appropriate articles addressing the issue at hand. The databases were searched from 1937 up to and including November 2010. In addition, reference lists including related books of original and review articles were also searched. The literature included in this review was published only in English. The search strategy used combined the key words *dental implants*, *complications*, *lingual artery*, *lingual foramina*, *bleeding*, and *anterior mandible*. The various techniques evaluated were radiographic examination, cadaver studies, and imaging studies such as computed tomography (CT) scans, limited cone beam CT (CBCT), magnetic resonance imaging, and ultrasound.

Eligibility Criteria

The following eligibility criteria were imposed. Studies needed to be experimental (animals and laboratory) or human (clinical). The studies identified the blood supply of the anterior mandible by anatomical, histologic, Doppler, or radiographic examinations. Case reports were not included. A reference list of potentially relevant research articles was used. Only articles published in the English language were included. Titles and abstracts of articles obtained using the aforementioned search strategy were screened by two of the authors (GER and BG) and examined for agreement on possible inclusion. The full texts of the articles deemed to be relevant according to title and abstract were read and evaluated independently against the stated eligibility criteria. Letters to the editor and unpublished articles were excluded. Any disagreements between the authors were resolved via discussion. Abstracts of all articles identified by the search were reviewed, and full texts were retrieved for the articles that fulfilled the eligibility criteria. Hand searching was not carried out.

RESULTS

The initial search strategy revealed 31 studies that were potentially eligible for inclusion. Based on the eligibility criteria, 14 studies were finally included in the review.[18,20–32] The 17 studies that did not satisfy the search criteria were excluded. The 14 included studies were subdivided into cadaver studies and radiographic or imaging studies. The findings are illustrated in Tables 1 and 2, respectively. Different papers reported that the sublingual artery is the main supply for the anterior mandible. Some articles reported a significant presence of the submental artery. A clear

Table 2 Blood Vessel Distribution in the Anterior Mandible Based on Radiographic and Imaging Studies

Author	Year	Findings
Lustig et al[22]	2003	Sublingual artery as the main artery (Doppler)
Tepper et al[24]	2001	Sublingual artery
Liang et al[27]	2005	Reported lingual artery and lingual foramina
Kawai et al[28]	2007	Sublingual artery
Longoni et al[34]	2007	Sublingual artery
Tagaya et al[18]	2009	Submental artery

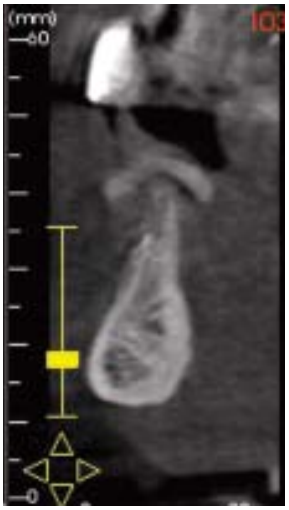

Fig 1 *(Left)* CT scan demonstrating the distribution of blood vessels in the symphysis.

Fig 2 *(Right)* Characteristic distribution of an endosseous artery in the anterior mandible; the artery penetrates the mandibular body from the lingual aspect.

anastomosis of the sublingual with the submental artery is shown in Fig 1, and a characteristic distribution of the endosseous arteries in the symphysis is shown in Fig 2. Risks of life-threatening hemorrhage have also been reported.[1–8,12–17]

DISCUSSION

The canine region has been the most frequently implicated site for life-threatening bleeding and airway obstruction among the reports in the literature.[7,11,16] However, information about intraosseous bleeding without perforation of the lingual cortical plate is not adequately presented in the literature; it is likely that only the life-threatening incidences of bleeding in conjunction with implant placement have been reported. Most of these reports state that drilling of about 15 mm and perforation of the lingual cortical plate caused the emergent situation. According to Loukas et al[20] and Rosano et al,[33] a depth of 15 mm is consistent with penetration of the perforating arterial branches. Sublingual arteries enter through the lingual canals at an average height of 10.3 mm from the crest of the ridge. Other authors have shown an anastomosis of the sublingual artery and the alveolar artery after penetration into the lingual cortical plate.[3,33]

The exact names and origins of the arteries are not as significant as an understanding of the complications related to perforation of the arteries. Some papers attribute this arterial supply to branches of the lingual artery, while others consider these branches of the facial artery. However, the fact that both parent arteries are branches of the external carotid artery is the most clinically significant. In a Doppler study, Lustig et al[22] clearly established that the blood flow is directed to the bone and has an arterial origin. The diameter of the vessel was 0.18 to 1.8 mm and the blood flow was about 0.7 to 3.7 mL/min. This may lead to significant consequences in dental settings during surgical procedures, such as minor oral surgery, bone harvesting techniques, and/or implant placement.

Many studies have looked at perforation of the lingual vascular canals; most have found at least one lingual canal and some have found up to five canals.[22–24,34] The course of the lingual canals in the

midline was described as advancing in a buccolingual direction, although there was difficulty visualizing the bone canals on a radiographic survey.[21] McDonnell et al[21] also emphasized that the lingual canal has an inclined path in relation to the lingual surface of the mandible, possibly affecting its visibility on radiographs. Hofschneider et al[23] were the first to detect these bone canals on CT scans. Tepper et al[24] described the intraosseous course of the lateral canals as moving in a ventral direction, while the canals in the midline coursed in a buccolingual direction. In a CT study, Tagaya et al[18] described the intraosseous paths of the canals from the foramina and the directions of the canals. Their courses could be observed on CT images in three distinct directions: above the mental spine, at the level of the mental spine, and below the mental spine. A recent CBCT study found a higher incidence (83.5%) of the incisive canal and the lingual foramen in the anterior region of the mandible.[36] The bone canals are extremely important anatomical structures that require extensive evaluation, especially prior to the placement of endosseous dental implants in the interforaminal region. The topography of the blood vessels in the anterior mandible must be assessed accurately prior to surgery to prevent profuse and life-threatening bleeding.

The presence of the midline and lateral lingual foramina has also been discussed in the literature. A frequency of 85% to 99% for the midline foramen has been reported.[21,24–27] Further studies by Lustig et al[22] and McDonnell et al[21] demonstrated poor visualization of the lingual foramen on periapical radiographs in comparison to its actual presence using CBCT studies. Katakami et al[19] reported a significant incidence of the midline lingual foramen; up to four midline lingual foramina were found. According to Kawai et al,[28] 66 of 68 dry mandibles examined with CT scans showed at least one foramen superior to the mental spine.

In a CT study, Tepper et al[24] observed the lateral lingual foramen in about 37 of 70 cases (approx. 50%). Early studies performed by Suzuki and Sakai[25] showed a frequency of 76% for the lateral lingual foramen and an average distance from the inferior margin of the mandible of 5 mm. This again explains the importance of using three-dimensional imaging techniques to provide a more accurate understanding of each patient's unique anatomy prior to surgery.

The clinician needs to be aware of the possible outcomes should endosseous bleeding occur intraoperatively and/or postoperatively. Endosseous bleeding during implant placement may disturb the wound-healing processes, leading to proliferation of the endothelial cells of the blood vessels around the implant surface and possibly compromising integration of the implant.

Detailed diagnostics of the bone morphology, including the shape and inclination of the alveolar ridge as well as osseous undercuts of the mandibular body, are crucial before surgery in the mandibular symphysis. Today, cone beam technology allows additional analysis of the possible presence of endosseous blood vessels. This technique may be used routinely to significantly reduce the radiation dose received by the patient.[37]

In light of the aforementioned facts, intraosseous bleeding is a fairly likely possibility, even if the lingual cortical plate is not perforated, especially in patients with advanced atrophy in the anterior mandible. Worldwide, a large number of implants are being placed every year in the symphysis region, increasing the quality of life for edentulous patients. A sound preoperative diagnostic evaluative technique is frequently not used, despite the many reports of life-threatening bleeding. The dental CT scan provides valuable information about the important anatomical aspects of the anterior mandible. This may help specialists and general practitioners plan this kind of surgical procedure and prevent intraoperative or postoperative complications. The development of cone beam technology makes it possible to analyze the anatomical limitations of the anterior mandible more precisely while significantly reducing radiation risks for the patient.

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REFERENCES

1. Flanagan D. Important arterial supply of the mandible, control of an arterial hemorrhage, and report of a hemorrhagic incident. J Oral Implantol 2003;29:165–173.
2. Kalpidis C, Setayesh RM. Hemorrhaging associated with endosseous implant placement in the anterior mandible: A review of the literature. J Periodontol 2004;75:631–645.
3. Krenkel C, Holzner K. Lingual bone perforation as causal factor in threatening hemorrhage of the mouth floor due to a single tooth implant in the canine region. Quintessence Int 1986;37:1003–1008.
4. Laboda G. Life-threatening hemorrhage after placement of an endosseous implant: Report of case. J Am Dent Assoc 1990;121:599–600.
5. Mason ME, Triplett RG, Alfonso W F. Life threatening hemorrhage from placement of a dental implant. J Oral Maxillofac Surg 1990;48: 201–204.
6. ten Bruggenkate CM, Krekeler G, Kraaijenhagen HA, Foitzik C, Oosterbeek HS. Hemorrhage of the floor of the mouth resulting from lingual perforation during implant placement: A clinical report. Intl J Oral Maxillofac Implants 1993;8:329–333.
7. Darriba MA, Mendonca-Caridad JJ. Profuse bleeding and life-threatening airway obstruction after placement of mandibular dental implants. J Oral Maxillofac Surg 1997;55:1328–1330.
8. Mordenfeld A, Andersson L, Bergstorm B. Hemorrhage in the floor of the mouth during implant placement in the edentulous mandible: A case report. Int J Oral Maxillofac Implants 1997;12:558–561.

9. Panula K, Oikarinen K. Severe hemorrhage after implant surgery [letter to the editor]. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1999;87:2.
10. Givol N, Chaushu G, Halamish-Shani T, Taicher S. Emergency tracheostomy following life threatening hemorrhage in the floor of the mouth during immediate implant placement in the mandible canine region. J Periodontol 2000;71:1893–1895.
11. Niamtu J III. Near fatal obstruction after routine implant placement. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2001;92:597–600.
12. Boyes-Varley JG, Lownie JF. Hematoma of the floor of the mouth following implant placement. J South Afr Dent Assoc 2002;57:64–65.
13. Weibrich G, Foitzik CH, Kuffner H. Life-threatening oral hemorrhage into the distal right mandible. Mund Kiefer Gesichtschirurg 2002;6:442–445.
14. Isaacson TJ. Sublingual hematoma formation during immediate placement of mandibular endosseous implants. J Am Dent Assoc 2004;135:168–172.
15. Kalpidis CD, Konstantinidis AB. Critical haemorrhage in the floor of the mouth during implant placement in the first mandibular premolar position: A case report. Implant Dent 2005;14:117–124.
16. Woo BM, Al-Bustani S, Ueeck BA. Floor of the mouth haemorrhage and life-threatening airway obstruction during immediate implant placement in the anterior mandible. Int J Oral Maxillofac Surg 2006; 35:961–964.
17. Dubois L, de Lange J, Baas E, Van Ingen J. Excessive bleeding in the floor of the mouth after endosseous implant placement: A report of two cases. Int J Oral Maxillofac Surg 2010;39:412–415.
18. 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;4:351–355.
19. Katakami K, Mishima A, Kuribayashi A, Shimoda S, Hamada Y, Kobayashi K. Anatomical characteristics of the mandibular lingual foramina observed on limited cone-beam CT images. Clin Oral Implants Res 2009;20:386–390.
20. Loukas M, Kinsella CR Jr, Kapos T, Tubbs RS, Ramachandra S. Anatomical variation in arterial supply of the mandible with special regard to implant placement. Int J Oral Maxillofac Surg 2008;37:367–371.
21. McDonnell D, Reza Nouri M, Todd ME. The mandibular lingual foramen: A consistent arterial foramen in the middle of the mandible. J Anat 1994;184:363–369.
22. Lustig JP, London D, Dor BL, Yanko R. Ultrasound identification and quantitative measurement of blood supply to the anterior mandible. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2003;96:625–629.
23. 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;14:379–383.
24. Tepper G, Hofschneider UB, Gahleitner A, Ulm C. Computed tomographic diagnosis and localization of bone canals in the mandibular interforaminal region for prevention of bleeding complications during implant surgery. Int J Oral Maxillofac Implants 2001;16:68–72.
25. Suzuki M, Sakai T. The foramina on the lingual surface of the mandible in the Japanese. Med J Shinahu Univ 1957;2:1–8.
26. Vandewalle G, Liang X, Jacobs R, Lambrichts I. Macroanatomical and radiologic characteristics of the superior genial spinal foramen and its bony canal. Int J Oral Maxillofac Implants 2006;21:581–586.
27. Liang X, Jacobs R, Lambrichts I, et al. Microanatomical and histological assessment of the content of superior genial spinal foramen and its bony canal. Dentomaxillofac Radiol 2005;34:362–368.
28. Kawai T, Asaumi R, Sato I, Yoshida S, Yosue T. Classification of the lingual foramina and their bony canals in the median region of the mandible: Cone beam computed tomography observations of dry human mandibles. Oral Radiol 2007;23:42–48.
29. Bavitz JB, Harn SD, Homze EJ. Arterial supply to the floor of the mouth and lingual gingival. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1994;77:232–235.
30. Ennis LM. Roentgenographic variations of the maxillary sinus and the nutrient canals of the maxilla and mandible. Int J Orthod Oral Surg 1937;23:173–193.
31. Mardinger O, Manor Y, Mijiritsky E, Hirshberg A. Lingual perimandibular vessels associated with life-threatening bleeding: An anatomic study. Int J Oral Maxillofac Implants 2007;22:127–131.
32. Przystańska A, Bruska M. Accessory mandibular foramina: Histological and immunohistochemical studies of their contents. Arch Oral Biol 2010;55:77–80.
33. Rosano G, Taschieri S, Gaudy JF, Testori T, Del Fabbro M. Anatomic assessment of the anterior mandible and relative hemorrhage risk in implant dentistry: A cadaveric study. Clin Oral Implants Res 2009;8:791–795.
34. Longoni S, Sartori M, Braun M, et al. Lingual vascular canals of the mandible: The risk of bleeding complications during implant procedures. Implant Dent 2007;16:131–138.
35. Gahleitner A, Hofschneider U, Tepper G, et al. Lingual vascular canals of the mandible: Evaluation with dental-CT. Radiology 2001;220: 186–189.
36. Makris N, Stamatakis H, Syriopoulos K, Tsiklakis K, van der Stelt PF. Evaluation of the visibility and the course of the mandibular incisive canal and the lingual foramen using cone-beam computed tomography. Clin Oral Implants Res 2010;21:766-71.
37. Scarfe WC, Farman AG. What is cone-beam CT and how does it work? Dent Clin North Am 2008;52:707–730.