

## ANATOMICAL CONSIDERATIONS FOR PLACEMENT OF DENTAL IMPLANTS IN THE MANDIBLE

Anoopsaran Bhojwani, Milind Karmarkar, Maya Dalaya, Mahesh Ghadage,  
Hemant Jadhav and Nilesa Kadam

Department of Prosthodontics, Bharati Vidyapeeth (Deemed to be University), Dental College and Hospital

### ARTICLE INFO

#### Article History:

Received 13<sup>th</sup> June, 2019

Received in revised form 11<sup>th</sup>

July, 2019

Accepted 8<sup>th</sup> August, 2019

Published online 28<sup>th</sup> September, 2019

#### Key words:

Placement of dental  
Implants

### ABSTRACT

The advent of implants in the field of dentistry has given the dental professionals a viable option to provide patients with a third set of dentition. With increasing numbers of implant surgeries performed, there is an increased risk of complications. It is essential for a dental practitioner to have a thorough knowledge of anatomical and prosthodontic considerations for accurate implant placement to avoid complications and deliver the patient an Esthetic and Functional Occlusion. In this article, a brief review is given about the anatomical considerations that are significant for treatment planning. The planning includes the evaluation of different anatomical boundaries such as inferior alveolar canal, incisive canal, mental foramen, width and height of available bone, and prosthetic driven implantology.

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### INTRODUCTION

A thorough understanding of the anatomy is a must for the implant surgeon to perform surgery with confidence whether to resect or augment tissues to restore the form, function and esthetics.<sup>1</sup> This article reviews the practical application of prosthetic driven implantology in the edentulous or partially edentulous mandible. We shall be focusing on Blood supply, Innervations and Muscle attachments of the mandible.

#### Innervation of the Lower Jaw and Associated Structures

1. Inferior alveolar nerve
2. Mental nerve and foramen
3. Lingual nerve
4. Nerve to mylohyoid
5. Long Buccal Nerve (Fig 1)

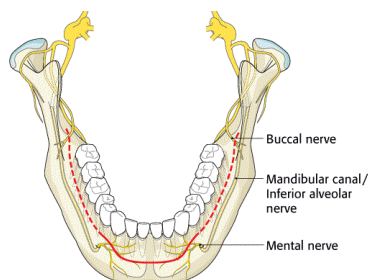


Fig 1

#### Innervation of the lower jaw

##### Inferior Alveolar Nerve

Inferior alveolar nerve is a branch of mandibular division of trigeminal nerve which arises from the infra temporal fossa. The inferior alveolar nerve appears at the inferior border of the inferior head of lateral pterygoid muscle. It enters the mandibular canal on medial surface of ramus by lingula. From its entrance into the mandible via the mandibular foramen until its exit from the mental foramen, this nerve is known as the inferior alveolar nerve (IAN). Within the canal there is a nerve, an artery, a vein and lymphatic vessels. The canal is approximately 3.4mm wide and nerve is approximately 2.2 mm thick.<sup>1,2</sup> The artery runs almost parallel with the nerve but its position varies as it lies superior or inferior to the nerve, therefore there are cases reported that have neurologic damage reported without any provoked haemorrhage and vice-versa.

The location of mandibular canal radiographically has been classified as

1. High : Within 2mm of the apices of first and second molars
2. Intermediate
3. Low
4. Other Variations: Duplication or division of the canal, lack of symmetry, partial or complete absence of

\*Corresponding author: Anoopsaran Bhojwani

Department of Prosthodontics, Bharati Vidyapeeth (Deemed to be University), Dental College and Hospital

canal, bifurcation of the canal . A bifurcated canal may manifest more than one mental foramen.<sup>3</sup>

Denio *et al* evaluated cadavers to determine how close the IAN was to the apices of mandibular posterior teeth. The mean distance to the second molar, first molar and premolars was 3.7,6.9 and 4.7 mm, respectively.

Levine *et al* conducted a study wherein they measured the distance between the edentulous alveolar crest and the superior aspect of mandibular canal and concluded that canal lied approximately 17.4mm inferior to the alveolar crest.

Littner *et al* reported the upper border of the mandibular canal was located 3.5 to 5.4 mm below the root apices of first and second molars.

Kim *et al* classified the location of the mandibular canal in the buccolingual location into three types

- Type 1: Canal follows the lingual cortical plate at the mandibular ramus and body (70 %)
- Type 2: Canal follows the middle of the ramus behind the second molar and the lingual plate passing through the second and first molars (15 %)
- Type 3: Canal follows the middle or the lingual 1/3<sup>rd</sup> of the mandible from the ramus to the body.<sup>3</sup>

### Injury to the Nerve

The inferior alveolar nerve is the most common nerve to get injured during dental implant surgery(64%).Nerve injuries can occur during the time of the surgery(intra-operative) or post-operatively. Nerve injuries that occur during the time of the surgery fall into two basic categories, intraoperative injuries maybe a result of thermal, chemical or mechanical events. Post operative injuries maybe ischaemia or scarring associated with localized hematoma or the residual effect of thermal injury. Chemical injuries may be due to the injection of a more potent local anaesthesia directly into the canal usually caused by prilocaine or articaine and rarely by lidocaine since it is least irritating to the tissues. In severely atrophied mandibular ridges, that require sufficiently long fixtures that cannot be placed without encroaching on the inferior alveolar nerve (IAN).<sup>2</sup> In this situation, restorative options include the use of short fixtures, onlay bone grafting to increase ridge height, and other complicated procedures. Another option is to move the IAN laterally from its canal by either nerve lateralization (IANL). With nerve lateralization, the IAN is exposed and traction is used to deflect it laterally while the implants are placed. The IAN is then left to fall back into position, against the fixtures. With this procedure, there is no interference with the incisive nerve. With nerve transposition, a corticotomy is done around the mental foramen and the incisive nerve is transacted, such that the mental foramen is repositioned more posteriorly.<sup>4</sup>

### Mental Nerve and Foramen

When the inferior alveolar nerve reaches the premolar region it is divided into the mental and the incisive nerves. The mental nerve exits the mental foramen and gives off three small branches. One of the branches innervates the skin of the chin and the other two innervate the lower lip, the gingiva and the mucous membrane as far posterior as the second premolar The incisive nerve innervates the teeth anterior to the mental foramen: the incisors, canines and the first premolars (Juodzbalys 2011). Recent studies have confirmed the

existence of an incisive canal located medial to the mental foramen, which is believed to be a continuation of the mandibular canal. The incisive canal is not usually well defined on radiological studies and its neurovascular bundle may meander through large intra-trabecular spaces in the anterior tip of the mandible (Greenstein and Tarnow 2006). The location of the mental foramen may differ in horizontal or vertical planes. It may be present in between the apices of two premolars or it may be seen below the apex of mandibular second premolar. Rarely, it is seen adjacent to the apices of first molar or canine. The position also varies in vertical plane it may present coronal to the apex (24%), at the apex (14%) or apical to the apex (62%) of second premolar. In an excessively resorbed mandibular ridge, the mental foramen with its contents of mental nerve and vessels can be found on the crest of the ridge.<sup>5</sup>When making an incision or reflection of mucosa in this area caution must be taken to preserve injury.

The anterior loop of the IAN is an important anatomical variation that originates from the IAN. An anterior loop of mental nerve emerges as the mental canal, which begins from the mandibular canal and passes in outer, upper, and backside directions to summit at the foramen mentale. In its first portion, it dips downwards and is then displaced upward and posteriorly to exit the mental foramen. Failure to note this mesial loop may cause complications like sensory disorders in the lower lip. Therefore, precise evaluation of its position before surgery is essential. In a study by Solar *et al.* categorized into two groups, loop and non-loop types depending on the occurrence of loop. Hun *et al.* in their cadaver study divided the loops into linear (straight) and upright (vertical). The straight pattern was visible as a mild slope of mental canal entering instantly into the foramen mentale and vertical (upright) pattern was visible when it is curved at right angles into the foramen. Fabian from measurements of 100 Tanzanian mandibles concluded that the direction of MF opening was superiorly in 44%, posterosuperiorly in 40%, labially in 10%, mesially (anteriorly) in 3%, and posteriorly in 3% of cases.

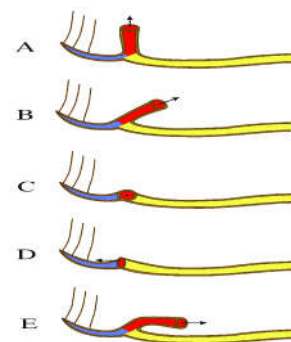


Fig 2

Emergence patterns of the mental canal and mental foramen opening. Colours: blue = Mandibular incisive canal, red = mental canal (the anterior opening of the mandibular canal) yellow = mandibular canal. A = superiorly, B = posterosuperiorly; C = labially; D = mesially (anteriorly); E = posteriorly<sup>6</sup> (Fig 2)

The classification described by Solar *et al.* In this classification, three different types have been introduced for the anterior loop. According to this classification,

- Type I : the anterior loop is not seen. The anatomy is Y-shaped and incisive branch thickness is similar to the main branch.

Type II: the anterior loop is absent but the anatomy is T-shaped. The incisive branch is perpendicular to the main branch and the mental branch enters the mental foramen in a perpendicular direction.

Type III: the anterior loop is detectable and the anatomy is Y-shaped. The incisive branch is thicker than the main branch and the mental branch diverges from the IAN anterior to the mental foramen (most common)<sup>7</sup>

Direct trauma may induce pain, sensory disturbance, and increased bleeding during or after an operation. Particular attention must be paid during the insertion of implants in the premolar region. Studies have reported sensory disturbance lasting 3–16 months after the insertion of implants in the interforaminal region. As a result, researchers have proposed that a safe area should be left between the distal surface of the implant and mesial surface of the mental foramen. However, they have recommended different safe area distances, such as 1 mm, 2 mm, 3 mm, 4 mm, and 6 mm. Considering the difference among the minimum, maximum, and mean values, it may be risky to rely on a standard safe area before implant applications, hence a CBCT is a must for planning of an implant procedure in this region.

### Lingual Nerve

The lingual nerve is a branch of the mandibular nerve that is given off in the infratemporal fossa. It is a sensory nerve that supplies the mucous membrane of anterior two-third of the tongue, lingual mucosa, mucosa of the floor of mouth. The chorda tympani (a branch of the facial nerve, CN VII) joins it at an acute angle here, carrying taste fibers from the anterior two thirds of the tongue and parasympathetic fibers to the submandibular ganglion. The nerve then passes between the medial pterygoid muscle and the ramus of the mandible, and crosses obliquely to the side of the tongue beneath the constrictor pharyngis superior and styloglossus, and then between the hyoglossus and deep part of the submandibular gland; it finally runs from laterally to medially inferiorly crossing the duct of the submandibular gland, and along the tongue to its tip becoming the sublingual nerve, lying immediately beneath the mucous membrane. This is the second most common nerve to get injured during implant surgery 24.4%. Improper reflection of a lingual mucoperiosteal flap may injure the lingual nerve and produce ipsilateral paresthesia, loss of taste and reduction in salivary secretion.<sup>1,8</sup>

### Nerve to Mylohyoid

The mylohyoid nerve is a branch of the inferior alveolar nerve. It arises just prior to where the IAN enters the mandibular foramen. This branch descends in a groove on the medial surface of the mandibular ramus and then appears in the submandibular triangle at the posterior border of the mylohyoid muscle. This is a motor nerve that supplies the mylohyoid muscle and the anterior belly of digastric muscle. This nerve may contribute to an inability to attain complete anaesthesia due to accessory sensory innervations to the anterior and posterior mandibular teeth. In such patients additional infiltration of local anaesthetic agent may be required to overcome the same.<sup>1,8</sup>

### Long Buccal Nerve

It is a branch of the mandibular nerve (which is itself a branch of the trigeminal nerve) and transmits sensory information from skin over the buccal membrane (in general, the cheek)

and from the second and third molar teeth. It courses between the two heads of the lateral pterygoid muscle, underneath the tendon of the temporalis muscle, and then under the masseter muscle to connect with the buccal branches of the facial nerve on the surface of the buccinator muscle. Small branches of the buccal nerve innervate the lateral pterygoid muscle. It also gives sensory branches to the cheek. An anatomic variation of the long buccal nerve, called Turner's variation, consists of the nerve emerging from a foramen in the retromolar fossa. When this variation exists, trauma in this region can cause paresthesia to the adjacent gingival and mucosa. The implantologist who is planning to access the ramus for the purpose of excising a block graft should be aware of the buccal nerve and avoid injuring it. In addition surgical manipulation in this area may injure the nerve.<sup>1,8</sup>

### Management of Nerve Injury

Some patients may complain of altered nerve sensation after implant surgery. Management of the nerve injury will depend on the cause of nerve injury, proper identification of the injured nerve is a must. If it is due to implant insertion, implant can be "unscrewed" and removed completely or else the impinging threads of implant on the nerve can be unscrewed to relieve the nerve. If the implant is osseintegrated a trephine drill can be used to loosen out the implant and remove it to relieve the nerve. Altered sensation wherein the implant does not appear to be impinging on the nerve have been observed by clinicians frequently. If injury has occurred during drilling the bone, a course of steroid can be prescribed to control the inflammatory reaction. Alternatively, a course of non steroidal anti-inflammatory drugs can be administered. Pain and temperature sensations are the first two sensations to recover followed by others.<sup>1,9</sup>

Frequently it is seen that traumatization of vital anatomical structures, neurologic injuries and severe bleeding in the floor of the mouth, which can be fatal if it causes upper airway obstruction may be caused do perforation of lingual concavity or undercut which is a common finding in the posterior mandible, and ignoring this undercut may result in perforation of the lingual cortex.(Fig 3a) Thus, in order to prevent these complications, accurate radiographs are required to quantify the amount of bone, assess the location of adjacent anatomical structures and select the proper size of fixture and proper implant placement site. Type of ridge morphology (C: convex, P: parallel, U:lingual undercut), In convex type the base of the mandible below the mylohyoid ridge is wider than the crest, in parallel type the base of the mandible is parallel to the crest of the ridge, in undercut type, the base of the mandible is narrower than the crest of the ridge.(Fig 3b)

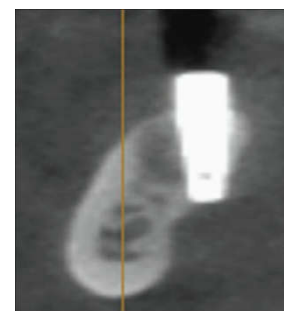
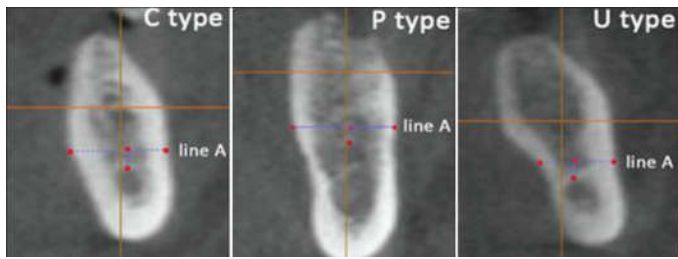


Fig 3a Perforation of lingual cortex





**Fig 3b** Type of ridge morphology (C: convex, P: parallel, U: lingual undercut)

If such an event occurs, implant should be removed immediately, and patient should be administered with steroids and/or non-steroidal anti-inflammatory drugs and follow up is a must.<sup>8</sup>

### Muscles of the Mandible

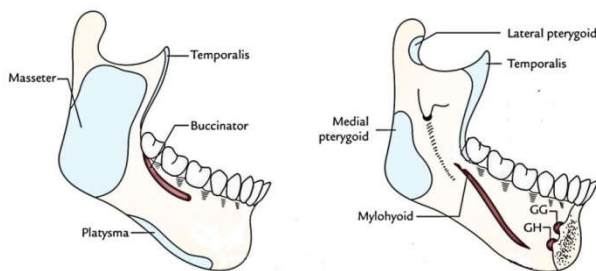
There are 26 muscles attached to the mandible among which there are 12 bilateral pairs of muscles and two single muscles (orbicularis oris and platysma). 12 Bilateral pairs are anterior belly of digastric, buccinator, depressor anguli oris, depressor labii inferioris, genioglossus, geniohyoid, masseter, mentalis, mylohyoid, lateral pterygoid, medial pterygoid, and temporalis. After the extraction of tooth there is alveolar bone loss, which decreases the width and height of bone. As the bone resorbs, the residual ridge migrates toward many of the muscles that originate or insert on the mandible. The muscles that are of concern to the dental implant surgeon are can be broadly classified into the lingual or medial attachments and buccal or facial muscle attachments.<sup>1,9</sup>

#### Lingual or medial attachments

1. Mylohyoid muscle
2. Genioglossus muscle
3. Medial Pterygoid muscle
4. Lateral Pterygoid muscle
5. Temporalis muscle

#### Buccal or Facial Muscle Attachments

1. Mentalis muscle
2. Buccinator muscle
3. Masseter muscle ( Fig 4 )



**Fig 4** Muscle attachments of the mandible

#### Lingual or Medial Attachments

##### Mylohyoid muscle

The mylohyoid muscle is the main muscle of the floor of mouth. Two flat triangular mylohyoid muscles take origin from the entire length of mylohyoid lines on the medial aspect of the mandible bilaterally. The fibres of this muscle are divided into three groups, anterior, middle and posterior fibres. The posterior fibres insert into the body of hyoid bone. The anterior and middle fibres insert into the median raphe between mandible and hyoid bone. This muscle is innervated by the nerve to mylohyoid and elevates floor of mouth in first stage of deglutition, depresses the mandible and elevates the

hyoid bone. While restoring the posterior mandible, in severely resorbed mandibular ridge, the origin of mylohyoid muscle approximates the crest of the ridge. Surgical complications such as edematous swelling of the sublingual space (above the mylohyoid muscle), swelling of the submandibular space (below the mandibular muscle), ecchymosis due to accumulation of blood, severe complications such as extensive bilateral cellulitis may result in airway obstruction and necessitate an immediate intervention such as tracheostomy or cricothyroidotomy. To avoid injury to this muscle the mylohyoid muscle can be partially dislodged from its origin to facilitate lingual flap advancement initially, post-operatively the partially displaced mylohyoid muscle will reattach to the adjacent tissues.<sup>9,11</sup>

##### Genioglossus muscle

It is known as the “safety muscle of the tongue” since it is the only muscle that propels the tongue forward. The pair of extrinsic muscles originate from the superior genial tubercles and insert into dorsal surface of tongue and body of hyoid. While operating in this region one should be aware that complete detachment of the muscle from genial tubercle should not happen at any chance since it may lead to airway obstruction due to retrusion of the tongue. However partial elevation of the muscle should not be problematic.<sup>9,11</sup>

##### Medial Pterygoid muscle

The medial pterygoid or internal pterygoid muscle is a quadrilateral muscle of mastication and has a deep head and a superficial head. The deep head originates from the medial surface of lateral pterygoid plate and superficial head originates from the maxillary tuberosity and pyramidal process of palatine bone. The muscle inserts into the medial surface of angle of mandible. The muscle closes the jaw by elevating the mandible and helps in side to side movement of mandible along with the lateral pterygoid muscle. The medial pterygoid muscle bounds the pterygomandibular space medially. Infection to the pterygomandibular space can spread to the mediastinum because of its close proximity to parapharyngeal space. Care should be taken while exposing the tissues posteriorly to the maxillary tuberosity to avoid injury to the medial pterygoid muscle as few fibres origin from maxillary tuberosity.<sup>9,11</sup>

##### Lateral Pterygoid Muscle

This muscle of mastication has a superior and an inferior head. The superior head originates from the infratemporal fossa and inserts into anterior side of the condyle. The inferior head originates from the lateral surface of lateral pterygoid plate and insert in the pterygoid fovea. This muscle helps in depressing the mandible, protrusion of the mandible, and side to side movement of the mandible. Complications in relation to this muscle are very rare but contraction of this muscle in full arch subperiosteal implant may result in pain.<sup>9,11</sup>

##### Temporalis muscle

It is a broad, fan shaped muscle of mastication which is a powerful elevator and retractor of mandible. It origins from the temporal fossa and inserts into coronoid process of the mandible and retromolar fossa. The temporalis tendons and associated fascia serve as a common point for attachment for the transaction and the superior pharyngeal constrictor muscles , this temporalis tendon- fascial complex extends into the

retromolar triangle. Involvement of this area may lead to transaction and post-operative pain.<sup>9,10,11</sup>

#### **Buccal or Facial Muscle attachments:**

1. Mentalis muscle
2. Buccinator muscle
3. Masseter muscle

#### **Mentalis muscle**

The “pouting muscle” is a paired muscle of the lower lip present at the tip of the chin. The mentalis muscle originates from the mental tubercles and the sides of mental eminence and insert into the soft tissues of the chin and superiorly interdigitate with the orbicularis oris of the lower lip. While operating in this region, care should be taken not reflect the muscle completely as it may result in “witch’s chin” because of failure in muscle reattachment. If this complication has occurred, an elastic bandage can be applied externally to the chin for 4 days to help in reattachment of the muscle, also to prevent complete detachment of the muscle a proximal portion of the muscle can be left attached to the bone and reflect the distal portion, before suturing the mucosa, the proximal and distal portion should be sutured with resorbable sutures.<sup>1,9,11</sup>

#### **Buccinator muscle**

The quadrilateral muscle occupies the interval between the maxilla and mandible at the side of the face and forms the anterior part of the cheek. It originates from the alveolar process of maxilla and mandible, maxillary tuberosity, pterygoid hamulus, pterygomandibular raphe and the retromolar fossa of the mandible and the fibres of this muscle insert into the fibres of the orbicularis oris. Some patients may complain of episodic pain with mandibular subperiosteal implants and occasional swelling after heavy episodes of bruxism or mastication. This myositis may be due to detached transaction muscle. While operating in this region, it may be necessary to create an incision that provides periosteal fenestration and penetrates several millimetres into the submucosa thereby facilitating coronal repositioning of the flap as the submucosa is strongly attached to the buccinator muscle in the cheek region and orbicularis oris in the lip area.<sup>9,11</sup>

#### **Masseter muscle**

This elevator muscle of the jaw has a superficial and a deep head, which covers the lateral surface of ramus of mandible and angle of the mandible. The superficial head originates from the zygomatic arch and zygomatic process of the maxilla and inserts into the lower half and lateral surface of the mandible. The deep head originates from the posterior one third of the zygomatic arch and entire deep surface of the arch and inserts into outer surface of ramus of mandible. The space between the masseteric fascia and the muscle is a potential space known as the masseteric space, in this space if infection spreads it may lead to inflammation and trismus. While using mandibular ramus as a donor site for bone graft, part of the masseter muscle may be detached from the ramus when the periosteum is elevated in this area.<sup>9,11</sup>

#### **Blood supply to the mandible**

The main artery supplying the mandible is the inferior alveolar artery. It enters from the medial aspect of ramus of mandible and courses within the mandibular canal to enter the body of the mandible. The artery branches into two different terminal

arteries namely the mental and incisive arteries in the premolar region. The mental artery exits the mental foramen and supplies the region of chin and anastomoses with submental and inferior alveolar arteries. The incisive artery anastomoses with the artery of opposite side and this artery is often severed during harvest of a monocortical symphyseal block of bone for grafting resorbed ridges.<sup>9,11</sup>

## **CONCLUSION**

Good results need a proper treatment planning. As it is rightly said “with great power comes great responsibility”, should be applied in field of implantology. Knowledge of anatomy is a must and all the associated structures should be evaluated before implant surgery, wherever possible three dimensional radiographs such as cone beam computed tomography should be taken into consideration, and prior surgical stents should be fabricated. A safety margin of minimum 2 mm above the nerve should be kept in mind before drilling in the bone. Also to prevent heat generation in the bone use of cold saline should be taken into consideration.

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