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Relationship Between Facial Index and Needle Penetration Depth in Inferior Alveolar Nerve Block: A Cross-Sectional Study

Relación entre el Índice Facial y la Profundidad de Penetración de la Aguja en el Bloqueo del Nervio Alveolar Inferior: Un Estudio Transversal

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SUMMARY: The anesthesia technique for the inferior alveolar nerve (IAN) is commonly used for mandibular dental and surgical procedures. However, it has a high failure rate between 38 % to 77 %, often attributed to operator-related issues and anatomical variations. This study aims to quantify the average needle penetration depth during the IAN block procedure and their relationship with facial index and sex in adult patients. A cross-sectional study was conducted in 182 adult patients aged 18–45 years who required mandibular tooth extraction. Participants were classified according to their facial index (euryprosopic, mesoprosopic, or leptoprosopic) and sex. The average needle penetration depth for females was 24.24 mm (±3.66 mm) and 25.03 mm (±3.84 mm) for males. Regarding facial index, the euryprosopic group had the deepest average penetration (26.06 mm ± 3.27 mm), followed by the mesoprosopic group (25.28 mm ± 3.64 mm). Statistically significant differences in needle penetration length were observed between facial index groups ($p < 0.05$). The study found that euryprosopic individuals requiring deeper needle insertion for the IAN block. These findings suggest that facial index may serve as an additional factor to consider when determining needle depth, potentially enhancing the precision and success of the IAN block technique.

KEY WORDS: Inferior alveolar nerve block; Needle penetration; Facial index; Leptoprosopic; Sex; Dental anesthesia.

INTRODUCTION

The trunk anesthesia technique for the inferior alveolar nerve (IAN) involves the deposition of local anesthetic into the pterygomandibular space to block the IAN and the lingual nerve. This technique allows for surgical and dental procedures on the anesthetized hemimandible (Malamed, 2006). It is the most commonly used technique for mandibular procedures and also has the highest failure rate of all regional techniques used in dentistry (Malamed, 2006), with a clinical failure rate reported to range between 15 % and 20 % (Kanaa *et al*., 2009).

Several authors attribute these failure rates to both operator-related issues (Lai *et al*., 2006; Palti *et al*., 2011) and anatomical variations in patients themselves (Takasugi *et al*., 2000). Regarding these anatomical factors, Malamed (2006), notes that the needle penetration length for IAN block should range from 20 to 25 mm, although ultrasound studies have reported an average depth of 17 mm. Understanding this variable depth is crucial when selecting the appropriate size of the carpule needle. It has been described that shorter instruments exhibit less deflection (Kronman *et al*., 1994), which increases the technique's precision and reduces both the failure rate (Kataoka *et al*., 2001; Steinkruger *et al*., 2006) and the likelihood of complications such as transient facial paralysis (García Peñín *et al*., 2003).

In this regard, Khoury *et al*. (2011), emphasize that to achieve better success rates and provide safer, more effective anesthesia, knowledge of intraoral reference points should be complemented by the study of underlying structures. One of the extraoral clinical parameters used in dentistry is the facial index, which classifies the skeletal development and growth tendency into three types: euryprosopic, mesoprosopic, and leptoprosopic (Companioni Bachá *et al*., 2010). However, no studies have been found that estimate needle penetration depth in this technique based on an extraoral clinical parameter.

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The aim of this study is to quantify the average needle penetration length in adult patients requiring the direct trunk technique for IAN block, and to examine its relationship with facial index and sex parameters.

MATERIAL AND METHOD

Study Design and Setting. A cross-sectional study was designed following the STROBE guidelines for observational studies (Cartes-Velásquez & Moraga, 2016). The study was reviewed and approved by the Ethics Committee of the Faculty of Medicine, Universidad Austral de Chile, in 2015. Participants were voluntary patients treated at the dental emergency service of the "Centro de Salud Familiar (CESFAM) Jorge Sabat" in Valdivia, Chile.

Participants. The study included patients classified as ASA I and II, aged between 18 and 45 years, with no sex distinction, and indicated for mandibular tooth extraction due to diagnoses of irreversible pulpitis, root remnants, acute dentoalveolar abscess, and subperiosteal or submucosal abscesses with poor rehabilitative and/or endodontic prognosis. Patients who were pregnant, had trismus, were uncooperative due to stress, fear, or anxiety, had no bone contact during needle insertion, had facial deformities, or a history of maxillofacial surgery were excluded. A non-probabilistic convenience sampling method was used to obtain the sample.

The sample size was estimated at 136 individuals using the STATA software (v. 10.0, StataCorp, USA). The calculation was based on the average needle penetration lengths reported by Menke & Gowgiel (1979) and Hannan *et al*. (1999), of 17 mm and 19 mm, respectively, along with their respective standard deviations (SD = 2 mm). A significance level of 5 %, a power of 80 %, and subgroup analysis for facial index and sex were also considered.

Calibration. To calibrate the investigator performing the anesthetic technique, 20 subjects who met the inclusion criteria and required two mandibular extractions in separate surgical sessions were selected. The same anesthetic technique was applied with a 30-day interval between the two procedures. The intra-observer reliability (Aravena *et al*., 2014) of the investigator obtained a Pearson correlation coefficient of rho = 0.89.

Procedure. After obtaining voluntary consent to participate in the study, the calibrated operator performed the anesthetic technique for IAN block as described by Malamed (2006). The operator positioned themselves at the 8 and 10 o'clock positions for the right and left side blocks, respectively. The patient was placed in a semi-supine position to locate the needle entry point, and the syringe body was positioned at the commissure of the opposite side, resting on the lower premolars. The needle insertion point was located three-quarters of the way along the anteroposterior distance from the coronoid notch toward the deepest part of the pterygomandibular raphe, 10 mm above the occlusal plane. A 27 gauge, 0.1 mm × 40 mm needle (Terumo Corporation, Japan) was used, with a sterilized silicone rubber stopper placed at the needle tip (Fig. 1).

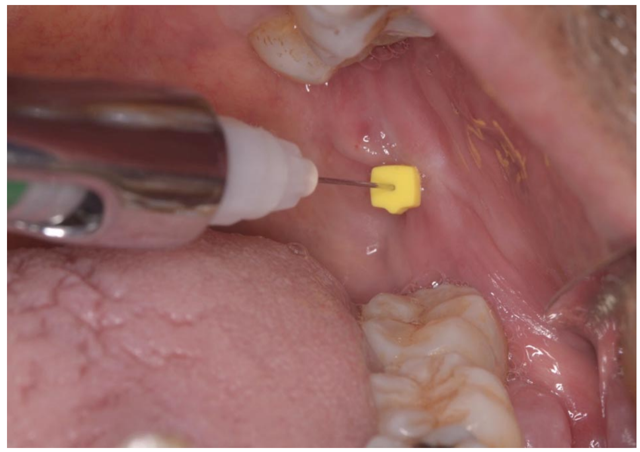

Fig. 1. Method for measuring the length of needle penetration in the technique of anesthetic block to the inferior alveolar nerve. A sterilized silicone rubber stopper was placed at the puncture site, which marked the distance of needle penetration until it touched the internal mandibular ramus. This length was then measured (in millimeters) using a digital caliper.

Needle penetration was measured by inserting the needle directly into the retromolar region until bone contact with the inner cortical surface of the mandibular ramus was reached, coinciding with the lateral limit of the pterygomandibular region, close to the inferior alveolar vasculonervous bundle (Khoury *et al*., 2011) (Fig. 2). After anesthetic deposition, the needle was withdrawn without making a second puncture. Finally, a second investigator measured the distance between the tip of the carpule needle and the most distal surface of the silicone stopper using a digital caliper (Mitutoyo, model Absolute Digimatic IP67, 150 mm - Brazil).

Facial Index Measurement. To correlate needle length with facial biotype, the facial index of each patient was measured with the face relaxed and looking straight ahead, using the same cephalometer as indicated above. Facial parameters described by Franco et al. (2013), were used: distance from ofrion to gnathion (facial height) and from one zygomatic arch to the other (facial width). The facial index was calculated as the ratio of facial height to facial width, multiplied by 100, classifying subjects into euryprosopic (values ≤ 97), mesoprosopic (values between 97 and 104),

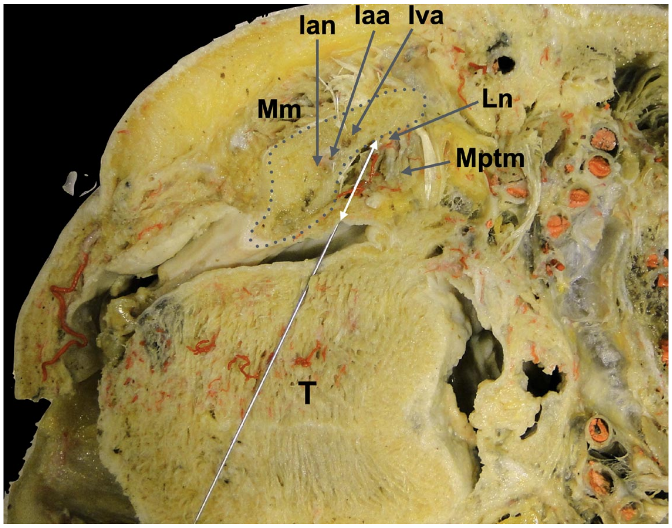

Fig. 2. Transverse section of human head at C1. It describes the pterygomandibular region with cut of mandibular ramus (dotted line), tongue (T) presence of inferior alveolar artery (Iaa), inferior alveolar vein (Iva), inferior alveolar nerve (Ian), lingual nerve (Ln), masseter muscle (Mm), and medial pterygoid muscle (Mptm). The penetration depth distance of the carpule syringe needle between the oral mucosa and the internal mandibular ramus is described (white double-headed arrow).

and leptoprosopic (values ≥ 104), as described by Companioni Bachá *et al*. (2010).

A third operator transcribed the patient's age (in years), gender (male/female), facial index (euryprosopic, mesoprosopic, and leptoprosopic), and needle length (in millimeters) into a Google Form document, which served as the database. Only the third investigator had access to the document.

Statistical Analysis. The observed dependent variables underwent a normality distribution analysis using the Shapiro-Wilk test ($p < 0.05$). An ANCOVA was then performed using STATA 10.0 (StataCorp, USA) for the needle penetration length variable, considering factors such as sex, puncture side, and facial index. When statistically significant differences were found, the Bonferroni test was applied to compare means. Finally, a linear regression analysis was conducted between needle penetration length and facial index across the different groups.

RESULTS

A total of 220 voluntary patients participated, with 197 meeting the inclusion criteria, and the needle penetration length could be determined in 182 patients. The average age was 34.4 ± 15.1 years, with 93 participants being female (51.1 %). Among the patients, 36.4 % (58 participants) had a leptoprosopic facial index, 31.8 % (66 participants) were mesoprosopic, and the remaining 31.8 % (58 participants) were classified as euryprosopic.

The Shapiro-Wilk test confirmed that the needle penetration values were normally distributed across the groups ($p = 0.11$). The average needle penetration length was 24.24 mm ± 3.66 mm (95 % CI: 24.49 - 25) for females and 25.03 mm ± 3.84 mm (95 % CI: 24.22 - 25.84) for males. Regarding facial index, the average needle penetration length was 26.06 mm ± 3.27 mm (95 % CI: 25.2 - 26.93) for the euryprosopic group, 25.28 mm ± 3.64 mm (95 % CI: 24.39 - 26.18) for the mesoprosopic group, and 22.45 mm ± 3.42 mm (95 % CI: 21.55 - 23.35) for the leptoprosopic group (Table I).

A simple linear regression analysis was conducted to examine the effect of the facial index on needle penetration depth, using the euryprosopic facial index as the baseline (constant = 26.06). The regression coefficient for the mesoprosopic group was -0.78, and -3.61 for the leptoprosopic group, with the latter being statistically significant (95 % CI: -4.88 to -2.37) (Table II).

Table I. Needle penetration length (in millimeters) according to facial biotype, sex, and puncture side.

Variable	N	%	Mean	SD	Min	Max	95% IC	p value
Female	93	51.1	24.24	3.66	14	33	24.49 - 25	0.15
Male	89	48.9	25.03	3.84	15	36	24.22 - 25.84	
Right	96	52.7	24.21	3.74	14	33	23.45 - 24.97	0.11
Left	86	47.3	25.1	3.74	16	36	24.3 - 25.9	
Euryprosopic	58	31.8	26.06	3.27	19	36	25.2 - 26.93	
Mesoprosopic	66	36.4	25.28	3.64	15	33	24.39 - 26.18	
Leptoprosopic	58	31.8	22.45	3.42	14	30	21.55 - 23.35	0,001
Total	182	100	24.63	3.76	14	36	24.08 - 25.18	

SD = Standard deviation. IC = Confidence interval<95%. p value= ANCOVA p<0,05

Table II. Regression analysis between facial index and needle penetration depth obtained through.

Facial index	Coef.	Std. error	p value	IC 95 %	
Euryprosopic	0				
Mesoprosopic	-0.78	0.62	0,21	-2.01	0.44
Leptoprosopic	-3.61	0.64	<0,001	-4.88	-2.34
Constant	26.06	0.45	<0,001	25.17	26.96

DISCUSSION

In this study, we quantified the needle penetration depth in the direct inferior alveolar nerve block technique according to sex and facial index parameters, observing a statistically significant difference in penetration depth in leptoprosopic patients compared to other facial biotypes.

The overall average needle penetration length was 24.63 mm, contrasting with the 20 mm described by Malamed (2006). It was not possible to find literature values for sex, facial biotype, or puncture side. More recently, the study by Al-Moraissi *et al.* (2021), investigated the impact of needle length and gauge on the success rate of IANB. They found that a 27-gauge needle, which is longer and thicker, was associated with a higher success rate compared to a 30-gauge needle. This suggests that a longer needle may be more effective in achieving successful nerve block, potentially due to better reach and stability during the procedure. These findings underscore the importance of considering both the anatomical landmarks and the physical characteristics of the needle when performing an IANB to optimize success and minimize complications.

The literature reports that failures in inferior alveolar nerve anesthesia range from 15 % to 20 % (Kanaa *et al*., 2009), occurring due to several factors, such as inadequate knowledge of anatomical structures, lack of experience, technical errors, patient anxiety, inflammation, infection, damaged anesthetic solutions, anatomical variations (Kronman *et al*., 1994; Blanton *et al*., 2003; Palti *et al*., 2011), limited mouth opening, improper needle placement (Madan *et al*., 2002), and needle deviation (Kataoka *et al*., 2001; Steinkruger *et al*., 2006).

Moreover, Lupi *et al*. (2001), found a consistent positioning of Spix's spine above or at the level of the occlusal plane, which suggests a predictable anatomical feature that may influence the depth of needle insertion. Notably, the absence of cases where the lingula was located below the occlusal plane further supports the idea that certain anatomical landmarks could be used to refine needle placement during IAN blocks. Additionally, the observed differences in the vertical distance from lingula to occlusal plane between males and females, with an average of 34.93 ± 17.46 mm across the sample, and more specifically the lower measurements in females (10.87 ± 16.56 mm), could offer insights into sex-based variations in needle penetration depth. These anatomical details may help improve the precision of IAN block techniques and reduce failure rates.

Understanding the depth of needle penetration becomes relevant to avoid injecting the solution into the parotid gland, which could result in facial paralysis that lasts as long as the anesthesia. Although this is a rare complication, it can be alarming for the patient. According to Keetley & Moles (2001), it has a low prevalence; however, after 580 punctures beyond the mandibular foramen during inferior dental block, they found an unexpectedly high incidence of facial paralysis of 0.3 %.

The finding of statistically significant differences in the average needle penetration depth according to the facial index suggests that this parameter might be associated with another factor that could trigger failures in the anesthetic technique. Moreover, the results of the linear regression between facial indices (Table II), using the euryprosopic facial index as the baseline, suggest that the leptoprosopic facial index has a negative correlation with penetration depth. That is, as the facial index value increases, the needle penetration depth decreases. This relationship was not statistically significant for the mesoprosopic and euryprosopic groups.

Regarding the study's limitations, the dependence on a single investigator for measuring needle penetration length and other patient-related factors, such as changes in the patient's position during needle penetration, needle deflection (Kronman *et al*., 1994), and tissue density at the puncture site (Khoury *et al*., 2011), are notable. These limitations were controlled by calibrating the primary investigator, using patient selection criteria, sample size calculation, and standardizing the anesthetic technique according to previously described recommendations (Malamed, 2006), thereby minimizing the risks of selection and measurement bias.

In conclusion, no statistically significant differences were found in needle penetration depth based on sex or puncture side in the direct inferior alveolar nerve block technique. Significant differences were only observed in patients with a leptoprosopic facial index. Additionally, a significant negative relationship between needle penetration depth and the leptoprosopic facial index was identified. Further research is needed to study these parameters, measuring the clinical anesthetic success rate in leptoprosopic patients or controlling each variable to explain the reported anesthetic failure rates in this technique.

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RESUMEN: La técnica anestésica para el bloqueo del nervio alveolar inferior (NAI) se utiliza comúnmente en procedimientos dentales y quirúrgicos mandibulares. Sin embargo, presenta una alta tasa de fracaso, que oscila entre el 38 % y el 77 %, atribuida con frecuencia a factores relacionados con el operador y a variaciones anatómicas. Este estudio tiene como objetivo cuantificar la profundidad media de penetración de la aguja durante el procedimiento de bloqueo del NAI y su relación con el índice facial y el sexo en pacientes adultos. Se realizó un estudio transversal en 182 pacientes adultos, de entre 18 y 45 años, que requerían extracción dental mandibular. Los participantes fueron clasificados según su índice facial (euriprosópico, mesoprosópico o leptoprosópico) y su sexo. La profundidad media de penetración de la aguja fue de 24.24 mm (±3.66 mm) en mujeres y 25.03 mm (±3.84 mm) en hombres. En cuanto al índice facial, el grupo euriprosópico presentó la mayor profundidad media de penetración (26.06 mm ± 3.27 mm), seguido del grupo mesoprosópico (25.28 mm ± 3.64 mm). Se observaron diferencias estadísticamente significativas en la longitud de penetración de la aguja entre los grupos según el índice facial ($p < 0.05$). El estudio concluyó que los individuos euriprosópicos requieren una inserción más profunda de la aguja para el bloqueo del NAI. Estos hallazgos sugieren que el índice facial puede ser un factor adicional a considerar al determinar la profundidad de la aguja, lo que podría mejorar la precisión y el éxito de la técnica del bloqueo del NAI.

PALABRAS CLAVE: Bloqueo del nervio alveolar inferior; Penetración de la aguja; Índice facial; Leptoprosópico; Sexo; Anestesia dental.

REFERENCES

Al-Moraissi, E. A.; Al-Selwi, A. M. & Al-Zendani, E. A. Do length and gauge of dental needle affect success in performing an inferior alveolar nerve block during extraction of adult mandibular molars? A prospective, randomized observer-blind, clinical trial. *Clin. Oral Investig., 25(8)*:4887-93, 2021.

Aravena, P. C.; Moraga, J.; Cartes-Velásquez, R. & Manterola, C. Validity and reliability in dental research. *Int. J. Odontostomat., 8(1)*:69-75, 2014.

Blanton, P. L.; Jeske, A. H.; ADA Council on Scientific Affairs & ADA Division of Science. The key to profound local anesthesia: neuroanatomy. *J. Am. Dent. Assoc., 134(6)*:753-60, 2003.

Cartes-Velásquez, R. & Moraga, J. Pautas de chequeo, parte III: STROBE y ARRIVE. *Rev. Chil. Cir., 68(5)*:394-9, 2016.

Companioni Bachá, A. E.; Torralbas Velásquez, A. & Sánchez Mesa, C. Relation between the aureal proportion and the facial index in students of Stomatology of La Habana. *Rev. Cuba. Estomatol., 47(1)*:31-9, 2010.

Franco, F. C.; de Araujo, T. M.; Vogel, C. J. & Quintão, C. C. Brachycephalic, dolichocephalic and mesocephalic: is it appropriate to describe the face using skull patterns? *Dental Press J. Orthod., 18(3)*:159-63, 2013.

García Peñín, A.; Guisado Moya, B.; Moreno, M. & José, J. Riesgos y complicaciones de anestesia local en la consulta dental: estado actual. *RCOE, 8(1)*:41-63, 2003.

Hannan, L.; Reader, A.; Nist, R.; Beck, M. & Meyers, W. J. The use of ultrasound for guiding needle placement for inferior alveolar nerve blocks. *Oral Surg. Oral Med. Oral Pathol. Oral Radiol. Endod., 87(6)*:658-65, 1999.

Kanaa, M. D.; Whitworth, J. M.; Corbett, I. P. & Meechan, J. G. Articaine buccal infiltration enhances the effectiveness of lidocaine inferior alveolar nerve block. *Int. Endod. J., 42(3)*:238-46, 2009.

Kataoka, H.; Washio, T.; Audette, M. & Mizuhara, K. *A Model for Relations between Needle Deflection, Force, and Thickness on Needle Penetration*. In: Niessen, W. J. & Viergever, M. A. (Eds.). Medical Image Computing and Computer-Assisted Intervention – MICCAI 2001. Berlin, Springer, 2001. pp.966-74.

Keetley, A. & Moles, D. R. A clinical audit into the success rate of inferior alveolar nerve block analgesia in general dental practice. *Prim. Dent. Care, 8(4)*:139-42, 2001.

Khoury, J. N.; Mihailidis, S.; Ghabriel, M. & Townsend, G. Applied anatomy of the pterygomandibular space: improving the success of inferior alveolar nerve blocks. *Aust. Dent. J., 56(2)*:112-21, 2011.

Kronman, J. H.; El-Bermani, A. W.; Wongwatana, S. & Kumar, A. Preferred needle lengths for inferior alveolar anesthesia. *Gen. Dent., 42(1)*:74-6, 1994.

Lai, T. N.; Lin, C. P.; Kok, S. H.; Yang, P. J.; Kuo, Y. S.; Lan, W. H. & Chang, H. H. Evaluation of mandibular block using a standardized method. *Oral Surg. Oral Med. Oral Pathol. Oral Radiol. Endod., 102(4)*:462-8, 2006.

Lupi, S. M.; Landini, J.; Olivieri, G.; Todaro, C.; Scribante, A. & Rodriguez Y Baena, R. Correlation between the Mandibular Lingula Position and Some Anatomical Landmarks in Cone Beam CT. *Healthcare (Basel), 9(12)*:1747, 2021.

Madan, G. A.; Madan, S. G. & Madan, A. D. Failure of inferior alveolar nerve block: Exploring the alternatives. *J. Am. Dent. Assoc., 133(7)*:843-6, 2002.

Malamed, S. F. *Handbook of Local Anesthesia*. London, Elsevier Health Sciences, 2013. pp.228-31.

Menke, R. A. & Gowgiel, J. M. Short-needle block anesthesia at the mandibular foramen. *J. Am. Dent. Assoc., 99(1)*:27-30, 1979.

Palti, D. G.; Almeida, C. M. de; Rodrigues, A. de C.; Andreo, J. C. & Lima, J. E. O. Anesthetic technique for inferior alveolar nerve block: a new approach. *J. Appl. Oral Sci., 19(1)*:11-5, 2011.

Steinkruger, G.; Nusstein, J.; Reader, A.; Beck, M. & Weaver, J. The significance of needle bevel orientation in achieving a successful inferior alveolar nerve block. *J. Am. Dent. Assoc., 137(12)*:1685-91, 2006.

Takasugi, Y.; Furuya, H.; Moriya, K. & Okamoto, Y. Clinical evaluation of inferior alveolar nerve block by injection into the pterygomandibular space anterior to the mandibular foramen. *Anesth. Prog., 47(4)*:125-9, 2000.

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