Доклади на Българската академия на науките
Comptes rendus de l'Académie bulgare des Sciences

Tome 77, No 8, 2024

MEDICINE

Oral medicine

DEFLECTION OF NEEDLES, USED FOR LOCAL ANESTHESIA IN THE DENTAL PRACTICE – COMPARATIVE STUDY

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Received on June 30, 2021
Presented by P. Vassileva, Member of BAS, on October 28, 2021

Abstract

The mandibular nerve blocks prove to be one of the most challenging anesthetic techniques for the dental practitioner. Many factors have a role in the success of these nerve blocks and one of them is the accuracy of the deposition of the anesthetic which can be influenced to a certain degree by the deflection of the injection needle.

In this study, three types of injection needles (Septoject XL 30G, Septoject XL 27G and Medoject 23G) were tested for deflection in a reversible hydrocolloid (agar-agar). They were divided into three groups of 30 needles each and were all inserted in the agar-agar at a depth of 20 mm with the help of a dental surveyor. Two mutually perpendicular radiographs were made for each needle in order to calculate the deviation in mm.

The results were analyzed and showed that the mean deflection in the 30G needles group was 5.32 ± 1.91 mm, the deviation in the 27G group – 3.37 ± 0.67 mm and none of the needles in the 23G group showed a deviation upon insertion in the hydrocolloid.

The results in this study showed that dentists should always prefer needles with a smaller gauge, because they provide smaller deflection figures and therefore better accuracy in the deposition of the anesthetic.

Key words: mandibular nerve block, deflection, injection needles

Introduction. Mandibular nerve blocks are one of the most challenging techniques for local anesthesia in the dental practice. Many factors can affect

https://doi.org/10.7546/CRABS.2024.08.15

the success of mandibular nerve blocks, some of which are anatomical variations, operator technique, and injection needle deflection. In the classic technique for mandibular nerve block anesthesia, the injection needle passes through various tissues. All these tissues will resist the penetration of the injection needle [1] and are the cause of its deflection, which is considered a significant factor in the failure of mandibular nerve blocks. In a detailed study of the anatomy in the region of the mandibular canal, Okamoto et al. [2] showed that the best anesthetic effect is achieved when the needle is inserted between the tendon of the temporalis muscle and the medial pterygoid muscle, directly in the pterygomandibular space. In most cases, this does not happen and the needle passes through the dense structures of the medial pterygoid muscle or the tendon of the temporalis muscle, which causes deflection of the needle. Although modern injection needles used in dental practice have excellent characteristics, there are still some inconsistencies in the choice of needle for local anesthesia. Some authors [3–6] recommend the use of needles with a relatively large lumen (23–25G), believing that the needles with a small lumen (27–30G) are too thin, tend to break and have too much elasticity, which makes them deflect more in the soft tissues. In addition, aspiration with smaller lumen needles is not always successful. However, most dentists, especially in Bulgaria, prefer to use needles with a smaller lumen. For example, according to Malamed [4], about 70% of dentists use 27G needles. In 1981, a telephone inquiry (direct communication with sales representatives in the San Antonio area) showed that 80% of the purchased local anesthesia needles in dental practice were 27G and 15% were 30G. Given the more frequent use of smaller needles by dentists, it is interesting to trace the difference in deflection between needles with smaller diameters and those with larger ones.

The aim of this study was to investigate the relationship between gauge and needle deflection, when doing mandibular nerve blocks.

Materials and methods. The study was performed with three types of injection needles with different diameters – Septoject XL 30G (0.3 × 25 mm), Septoject XL 27G (0.4 × 3 mm) and Medoject 23G (0.6 × 30 mm). The depth of penetration, that was tested was 20 mm.

A reversible agar-agar hydrocolloid was selected as the soft tissue-like medium according to Aldous [7]. To ensure that the needles entered at the same angle, a parallelometer (JT-10 Surveyor) was used. The needles were fixed to the axis of the parallelometer, and the hydrocolloid cylinder was placed on the table of the instrument.

The method for measuring the deflection is based on the study of Aldous [7]. The needle is inserted in the hydrocolloid at the specified depth and two radiographs with perpendicular to each other projections are made. To ensure the perpendicularity of the two X-ray projections, computer sensor holders (Planmeca ProSensor 1) and radiograph guides (Planmeca ProX) are fixed to the parallelometer table, which will ensure the accuracy of the radiographs. A level of 20 mm is determined for the insertion depth, which coincides with the average depth at which the needle must enter in order for the conduction anesthesia to be successful in most methods. To calculate the total deflection of the needle, two radiographs were taken for each needle in two mutually perpendicular projections, with the sensors transmitting the X-ray image to a computer. The penetration of the needles was limited to 20 mm by means of a silicone stopper. The deflection of the needle was calculated with a digital processing program (Fig. 1).

Fig. 1. Radiographs, showing the deflection in the hydrocolloid cylinder

The Pythagorean geometric theorem is used to calculate the total deflection of each needle. The deviation of the needle of each of the two films is taken as the side of a right triangle, and the total deflection is the hypotenuse of this triangle (Fig. 2).

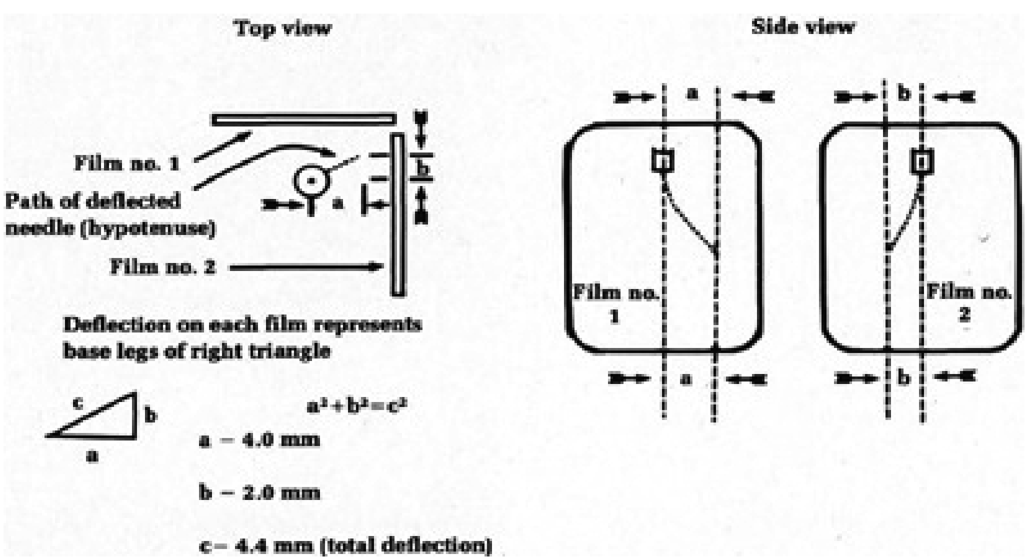

Fig. 2. The method for calculating the deflection of the needle, using two mutually perpendicular radiographic projections

A total of 90 needles were measured, and two radiographs with mutually perpendicular projections were made for each of them. All needles were inserted into the reversible hydrocolloid at a depth of 20 mm using the described procedure.

Results. From all the radiographs made and the measurement of the deflection of the 30G needles, respectively, the following results were found (Table 1). The mean deviation of the 30 needles is 5.32 ± 1.91 mm with a maximum deviation of 8.95 mm and a minimum deviation of 1.33 mm. The measurements of the needles 27G show an average value of deflection of 3.37 ± 0.67 mm, as the maximum reported deflection is 5.09 mm and the minimum is 2 mm (Table 1). All needles with 23G lumen do not give any deviation when inserted at a depth of 20 mm into the reversible hydrocolloid. The results show a greater deflection of the needles with a smaller gauge and, respectively, a smaller or completely absent deflection of the needles 27G and 23G.

Comparisons between the deflections of the three types of needles (in mm) are visualized in Table 1.

Table 1

Descriptive characteristics of the deflection of the three groups of needles

Type of needle	Volume N of the sample	Deflection (mm)	SD	95% CI for the mean deviation (mm)		min	max
				Lower limit	Upper limit		
30G	30	5.32	1.91	4.61	6.04	1.33	8.95
27G	30	3.36	0.67	3.12	3.62	2.00	5.09
23G	30	0	0	0	0	0	0

The Shapiro–Wilk test found that the data for the 30G and 27G needles were normally distributed, and the Levene test found that the dispersions were not equal. The third sample consists only of zeros, i.e. it is not normally distributed and has a variance of 0. Under these conditions, it was not possible to use one-way analysis of variance (ANOVA) to compare needle deflection and other methods had to be sought. As the situation is more specific due to the third sample, two methods were used in parallel and their results were compared:

1. **First method.** Since the sample of 23G needles shows zero variance, the comparison of the three types of needles was reduced to check whether the deflections of the 30G and 27G needles were statistically different from each other and from 0. For this purpose, the corresponding T-tests with Bonferroni correction were performed.

   1.1. The double application of the T-test to compare the mean with a number (One Sample T test) showed that the mean deviations given by the 30G and 27G needles were statistically significantly greater than 0 ($p < 0.001$ in both tests).

1.2. According to the T-Test for the comparison of two averages with uneven dispersions (T-Test: Two-Sample Assuming Unequal Variances), 30G needles give significantly larger deviations than 27G needles ($p < 0.001$).

2. **Second method.** For the three samples, the nonparametric Kruskal–Wallis H Test was applied to compare more than two means. It allows data that are not normally distributed and have different variances.

The test showed that the deflections of the three needles are not equal. To determine where the differences were, multiple comparisons were made by Dunn's (1964) method with Bonferroni correction. According to them, 30G needles give significantly larger deviations than 27G ($p = 0.013$) and 23G ($p < 0.001$) needles. 27G needles also had significantly greater deflection than 23G needles ($p < 0.001$).

The deflections of the three types of needles differ considerably, and the deviations they give are greater the thinner the needles, with the thickest needles giving zero deviations.

Discussion. Agar-agar was chosen for the purposes of this study because it is often used in other studies such as that of Yoshimura et al. [8] who indicate that this reversible hydrocolloid has a relaxation time similar to that of soft tissues in the human body. In the attempt to measure deflection, a parallelometer was used, through which the angle of insertion of the needle in the hydrocolloid is unified and is perpendicular to the reversible hydrocolloid. In a real setting, when doing mandibular nerve blocks, the angle of insertion of the needle is rarely perpendicular to the tissues due to a number of factors.

The study by Aldous [7] supports the data from the present experiments by identifying needles with a smaller diameter, prone to greater deflection, i.e. the deflection is inversely proportional to the diameter of the needles. Some studies link the deflection of needles not only to their diameter but also to the type of metal used in their production. One such study is that of Robinson [9]. It compares three different sizes – 25G, 27G and 30G needles, and three models are selected from each size – Monojet model 401 (metal hub), Monojet model 400 (plastic hub), and Hypo (metal hub). The needles are subjected to deflection, breakage and tensile tests. Ten needles from each group were tested. The results of the study do not show a statistical difference between the diameter of the needle and its deflection, but it shows that Hypo needles represent greater deflection in all sizes. Given that the needles of the different models have a similar tip cross-section, lumen size and wall thickness, the authors of the study attribute this to the differences in the material from which the needles are made.

The deflection of the needles is mainly due to the cross section of the needle tip. These arguments are supported by the study of Jeske and Boshart [10]. The study selected two types of needles – standard 25G needles with two lengths (short and long), and special needles with modified tip and diameter 28G, but with a modified tip cross section, which are also divided into subgroups (short and long). Each subgroup consisted of ten needles, and the results of the study eloquently show that 28G modified-tipped needles deflected significantly less, despite their smaller diameter, than those with 25G.

Some authors, such as Hochman and Friedman [11], describe that the length of needle insertion when doing inferior alveolar nerve blocks usually varies around 25 mm in depth. In the present study, a penetration length of 20 mm was selected, with the deflection of the needles being directly proportional to the depth of penetration of the needle in the hydrocolloid. From this it can be judged that with a deeper penetration into the agar-agar, the deflection of the needle will increase even more.

Another factor that strongly influences the deflection of the needle when it is inserted into the tissues is the penetration technique. In the present study, the deflection of the needles was tested by linear penetration of the needle into the medium, which mimics soft tissues. The study of Hochman and Friedman [11] examined the deflection of linear penetration and bilateral rotation of the needle when entering the medium/soft tissues. Mark compares needles with a diameter of 25G, 27G, 30G and their deflection was studied in three different media at a depth of 20 mm. The study shows that the rotary entry technique reduces needle deflection at all diameters and in all media.

Conclusion. The success of nerve blocks in the dental practice is multifactorial. One of the most problematic anesthetic techniques is inferior alveolar nerve block. Not all failures in nerve blocks of the lower jaw are due to needle deflection, but this is one of the factors that can reduce the accuracy of anesthetic deposition and thus reduce the chance of successful nerve block. The neurovascular bundle of the lower jaw has an average diameter of less than 2.2 mm [10], and for a successful block Malamed [12] believes that the anesthetic should be deposited up to 1 mm from the nerve. In this study, the average deviation of 30G diameter needles was 5.32 mm, with some needles showing a maximum deviation of 8.95 mm, which can be fatal for the accurate anesthetic deposition.

Therefore, the data from the present study suggest that dentists should prefer needles with a smaller deformation (needles with a larger diameter) when performing nerve block anesthesia.

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