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Original Research Article

Tomographic assessment of the position of the inferior alveolar nerve in relation to the lower third molars

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Abstract

Introduction: Third molars are the most frequently included or impacted teeth, with the highest incidence in the mandible. Surgical removal of these teeth requires careful preoperative assessment. Although panoramic radiography is widely used, its limitations include distortion and overlapping of structures. Cone beam computed tomography (CBCT) offers three-dimensional images, providing a more detailed analysis, especially for cases where there is a risk of injury to the inferior alveolar nerve (IAN). **Objective:** Therefore, the aim of this study was to evaluate the relationship between the position of the IAN and mandibular third molars, using CBCT scans taken from March 2023 to March 2024. **Results:** Of the 97 CBCTs evaluated, 91 were included. The trajectory inferior to the third molar was the most prevalent (28%), with contact with the IAN in 69% of cases. There was narrowing of the mandibular canal in 57% of the images and absence of cortical bone in 58%. The mesioangular position was the most frequent (39%) and the retromolar canal appeared in 4.4% of cases. **Conclusion:** However, these findings reinforce the importance of CBCT in surgical planning, allowing an accurate assessment of the relationship between the third molar and the IAN in order to reduce risks and complications.

Introduction

Third molars are the teeth most frequently described as included or impacted, accounting for approximately 98% of cases [6]. This condition is most frequently observed in lower third molars, and the probability of occurrence in the mandible is almost twice as high as in the maxilla [15]. Ethnicity and age of the population evaluated are factors that may influence this condition [15]. Corroborating these data, some authors reported that 73% of young adults had at least one included or impacted lower third molar [1].

The extraction of these teeth requires careful clinical and imaging analysis to assess the proximity of the roots of the lower third molars to the inferior alveolar nerve (IAN), since damage to this structure can result in paresthesia and functional, social and psychological problems [12]. Panoramic radiography and cone beam computed tomography (CBCT) are widely requested in the preoperative evaluation. Panoramic radiography is the most requested examination, as it allows a wide view of the dental arches and is easy to acquire and low cost. However, it is a two-dimensional technique that presents image distortions and overlapping of anatomical structures. Due to these limitations, CBCT has been progressively more requested because three-dimensional images optimize the assessment and allow greater predictability of risks in surgical planning [12].

Therefore, the assessment between the position of the lower third molar and the IAN must be performed to minimize the occurrence of surgical complications. Most studies in this context are based on the assessment of the position of the third molar in panoramic radiographs, which use the Winter classification [4, 11, 13, 16, 18]. Other authors [4] used a qualitative and quantitative analysis of panoramic radiographs of impacted third molars, associated with the methods of Winter (1926) and Pell and Gregory (1933). This approach was essential to determine the prevalence of different third molar positions, such as mesioangular and vertical inclinations. This methodology included the radiographic measurement of the angulation of the third molar in relation to the second molar, according to the classification of Winter (1926), accompanied by the evaluation of its position in relation to the mandibular ramus and the occlusal level, according to the criteria of Pell and Gregory (1933) [4]. However, due to the limitations inherent in two-dimensional examinations, the direct relationship between the third molar and the IAN was not adequately evaluated.

Similarly, other authors [11] also used panoramic radiographs to assess postoperative complications in extractions of impacted third molars. Winter's classification was used to categorize tooth positions, addressing the possible impact of these positions on the risk of injury to the IAN. In addition, the relationship between the root apices of lower third molars and the IAN was also investigated (Félez Gutiérrez, 1997) to assess signs of proximity between these structures through panoramic radiographs. The study highlighted the mesioangular position as the most prevalent, corroborating findings from other studies [3, 11]. However, other authors reported the vertical position as the most prevalent in panoramic radiographs using the Winter (1926) and Pell and Gregory (1933) classifications. This scenario was expanded with the evaluation of dental positions as well as their relationship with adjacent anatomical structures in panoramic radiographs and CBCT. However, 509 panoramic radiographs and only 37 CBCT were evaluated [16].

Thus, the aim of the study was to evaluate the trajectory of the inferior alveolar nerve and its relationship with lower third molars, using a spatial classification of the inferior alveolar nerve based on the concepts of Cartesian coordinates [9, 18]. In this Cartesian coordinate system, based on continuous buccolingual slices, the layer (or slice) where the inferior alveolar nerve (IAN) and the mandibular third molar were closest was selected as the reference image to determine their relative position. The apex limit of the mandibular third molar was identified to serve as the origin point in the Cartesian coordinate system. Thus, two perpendicular axes were drawn: the X-axis (horizontal) and the Y-axis (vertical). Subsequently, the position of the IAN was determined.

Material and methods

This observational and cross-sectional study was approved by the Research Ethics Committee (Coep #64.023.333). The study does not require the use of an informed consent form (ICF), since the data used come from a database.

The sample consisted of 97 examinations of patients over 18 years of age who underwent CBCT between March 2023 and March 2024 with indication for extraction of lower third molars. Six examinations that did not adequately cover the region of interest were excluded (n = 6), totaling 91 examinations. Demographic data such as gender and age were obtained through medical records.

The exams were acquired through the CS8200 computed tomography equipment (Carestream Dental, São Paulo, Brazil) of the Diagnostic Imaging Center of the State University of Ponta Grossa (Ponta Grossa, Paraná, Brazil) by a qualified professional. The kilovoltage (Kv) values were 90kV while the milliamperage (mA) values varied between 5 and 10mA. The field of view (FOV) varied according to the number of teeth to be removed: single tooth – FOV 5X5; 2 teeth (upper and lower on the right side or upper and lower on the left side) – FOV 8x9. In conditions characterized by two teeth on opposite sides or more teeth, FOV 12x5 or 12x10 was used. The analysis of images in DICOM (Digital Imaging Communications in Medicine) format was performed using the RadiAnt™ DICOM Viewer software (Medixant®, Poznan, Poland), available at https://www.radiantviewer.com, with a 23-inch LPS LED 23mp55 monitor (LG Corporation®, Seoul, South Korea), in a room with brightness control. The evaluation was performed by two trained and calibrated examiners, subjected to the kappa agreement test, obtaining intra-examiner values of (p=0.84) and inter-examiner values of (p=0.82).

Initially, sagittal, coronal and axial sections were evaluated. The classification of the position of the IAN and measurement of the distance between the tooth and the IAN were obtained in the coronal sections. The shortest distance between the two structures was considered. For the classifications, Cartesian coordinates were used, as mentioned in previous studies [9, 18]. Both studies utilized CBCT images, with the coronal slice as a reference for classifying the position of the inferior alveolar nerve. A study [9] categorized the IAN position into four groups: buccal, inferior, lingual, or between the roots. Other [18] analyzed the relationship between the nerve and the impacted third molars using classifications based on cylindrical and Cartesian coordinates, the latter being applied in the present study.

The distance between the lower third molar (3ºM) and the IAN was measured in millimeters in coronal sections, considering the smallest distance between them. Thus, the following classification was established: a) distant: more than 2 mm between 3ºM and IAN; b) close: less than 2 mm between 3ºM and IAN; c) in contact: distance of 0 mm between 3ºM and IAN (figure 1).

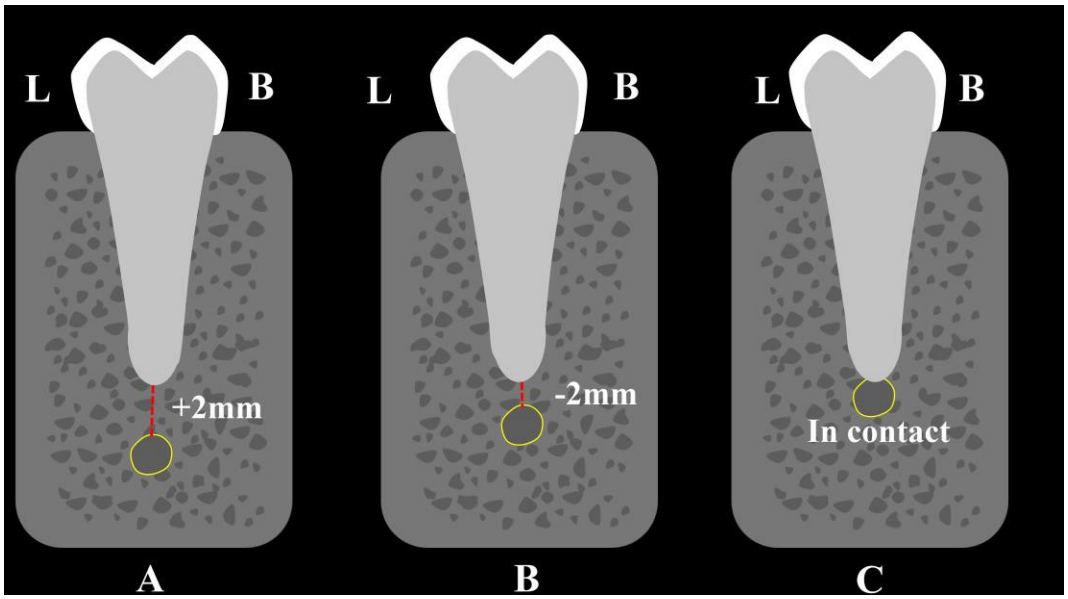

Figure 1 – Schematic representation of the distance between the IAN and the root apex of the lower 3rdM: A) +2 mm distance between IAN and lower 3rdM; B) -2 mm distance; C) 0 distance, contact between IAN and lower 3rdM. B) buccal; L) lingual

Source: The authors (2024, p. 7)

The classification of the IAN trajectory was based on the spatial position of the IAN in relation to the 3rd M. This evaluation was performed using the classification proposed by Miller *et al.* [10] and was divided into: lingual (L); vestibular (V); inferior (I); between the roots (ER); inferovestibular (I-V) or inferolingual (I-L) in relation to the tooth. Anatomical variations of the mandibular canal were also evaluated and classified as: a) retromolar canal; b) island canal; c) arm bifurcation (figure 2).

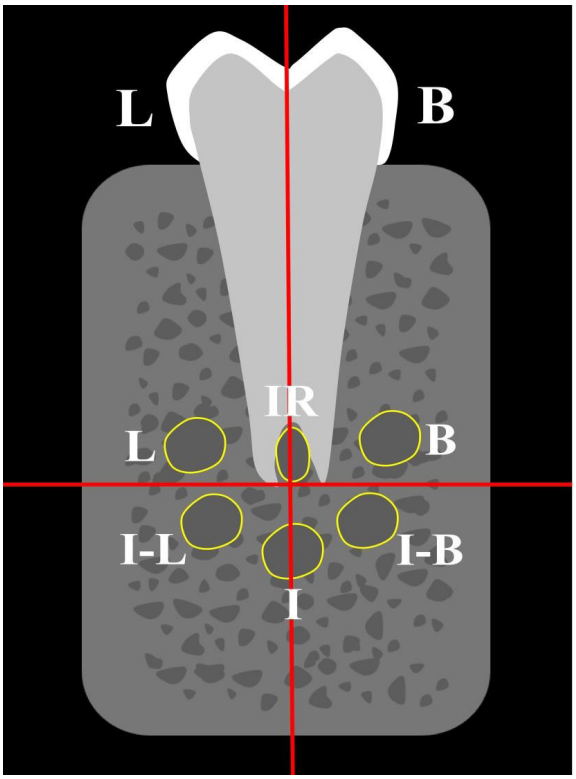

Figure 2 – Representative schematic drawing of the Cartesian plane used in the evaluations: B) buccal; I-B) infero-buccal; I) inferior; I-L) infero-lingual; L) lingual; IR) interradicular

Source: The authors (2024, p. 8)

The quantitative analysis of the Pell and Gregory classification was performed through the sagittal section, being classified as level 1, 2 or 3, according to the relationship with the mandibular ramus. In addition, they were classified as A, B or C according to the relationship of the distance with the occlusal plane. In Class 1, there is sufficient space available between the anterior border of the ascending ramus and the distal aspect of the 2nd molar. The space is more than the mesio-distal width of the crown of the 3rd molar. Class 2. The space available between the anterior border of the ramus and the distal aspect of the 2nd molar is less than the mesio-distal width of the crown of the 3rd molar. It denotes that the distal portion of the 3rd molar crown is covered by bone of the ascending ramus. Class 3. The 3rd molar is totally embedded in the bone of the ascending ramus because of the absolute lack of the space. Position A. The occlusal plane of the impacted tooth is at the same level as the occlusal plane of the 2nd molar, or above (The highest portion of the impacted 3rd molar is on a level with the occlusal plane, or above). Position B. The occlusal plane of the impacted tooth is between the occlusal plane and the cervical margin of the 2nd molar (The highest portion of the impacted 3rd molar is below the occlusal plane but above the cervical line of the 2nd molar). Position C. The occlusal plane of the impacted tooth is below the cervical margin of the 2nd molar (The highest portion of the impacted 3rd molar is below the cervical line of the 2nd molar).

According to Winter's classification, which addresses the angulation of the 3rd molar in relation to the adjacent second molar, the images were classified as: vertical, horizontal, mesioangular, distoangular, inverted, vestibuloangular, linguoangular and exceptional (when the tooth was outside the alveolar process or did not apply to other classifications). Data were subjected to descriptive statistical analysis (Jamovi software, Sydney, Australia) and expressed as absolute, relative and mean frequencies. In addition, Chi-square and Fisher tests (Jamovi software) were performed to assess the possible association between demographic variables (sex and age group). Values of $p<0.05$ were considered statistically significant.

Results

Ninety-one CBCT scans of 57 individuals with indication for extraction of lower third molars were analyzed. Regarding age distribution, 91.23% were between 18-35 years old; 7.02% were between 36-55 years old and 1.75% between 56-99 years old. In addition, 35.09% were male and 64.91% were female. In terms of the distribution regarding the analyzed tooth, 20.58% of the patients presented tooth 38; 19.11% presented tooth 48, and 60.29% presented both teeth (38 and 48) in the same tomographic examination. Regarding the quantitative analysis of the proximity between the 3rd molar and the IAN, 69.2% of the cases were classified as "in contact", 20.9% "close" and 9.9% "distant". Furthermore, approximately 57% of the cases presented luminal narrowing and 58.2% showed the absence of the mandibular canal cortex

for separation between the tooth and nerve bundle. Among those classified as "in contact", 40% were female and 23% were male. However, this difference was not significant (p value = 0.65, Chi-square test). The data did not present normal distribution (Shapiro-Wilk, p>0.05). Regarding the evaluation of the spatial position of the IAN in relation to the 3rd molar (table I), the most prevalent position was inferior in relation to the tooth (27.5%), while the least prevalent position was between the roots (2.2%) (figure 3).

Table I – Frequencies of the IAN trajectory in relation to the 3rd M

AN Trajectory	N Total	% Total	% Accumulated
Lingual	23	25.3%	25.3%
Buccal	11	12.1%	37.4%
Inferior	25	27.5%	64.8%
Interradicular	2	2.2%	67.0%
Infero-buccal	23	25.3%	92.3%
Infero-lingual	7	7.7%	100%

Source: The authors (2024, p. 11)

Quantitative table of the percentage of the IAN trajectory in relation to the lower 3ºM evaluated.

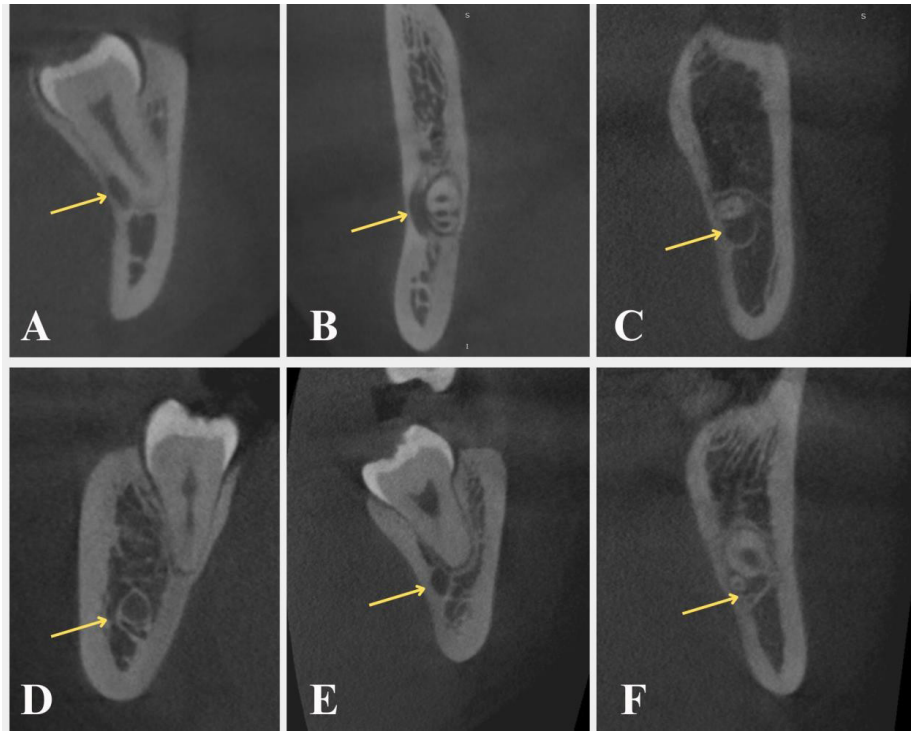

Figure 3 – Tomographic aspect of the different positions of the IAN in relation to the lower third molar. CBCT coronal sections showing the path of the IAN in relation to the 3rd molar: A) lingual; B) buccal; C) inferior; D) infero-buccal; E) infero-lingual; F) interradicular

Source: The authors (2024, p. 11)

There was an association between the contact of the IAN and the spatial position of the third molar (table II), and the highest prevalence of contact was detected in the lingual (24%) and inferior (23%) trajectories of the IAN in relation to the tooth ($p<0.01$).

Table II – Relationship between channel trajectory and distance from IAN

		Channel trajectory						
Distance		**Lingual**	**Buccal**	**Inferior**	**Interrradicular**	**Infero-buccal**	**Infero-lingual**	**Total**
Distant	Observed	0	0	2	0	7	0	9
	% of total	0%	0%	2.2%	0%	7.7%	0%	9.9%
Near	Observed	1	3	2	0	10	3	19
	% of total	1.1%	3.3%	2.2%	0%	11%	3.3%	20.9%
In contact	Observed	22	8	21	2	6	4	63
	% of total	24.2%	8.8%	23.1%	2.2%	6.6%	4.4%	69.2%
Total	Observed	23	11	25	2	23	7	91
	% of total	25.3%	12.1%	27.5%	2.2%	25.3%	7.7%	100%

Source: The authors (2024, p. 13)

Regarding anatomical variations, a retromolar canal was observed in 4.4% of cases. No other anatomical variations were detected. In the quantitative analysis of the position of the 3rd molar (according to the classification of Pell and Gregory, 1933), the most prevalent position was 2B (34%) (table III).

Table III – Frequencies according to the Pell and Gregory classification

Pell and Gregory	N Total	% Total	% Accumulated
1B	21	23.1%	23.1%
3B	6	6.6%	29.7%
2B	31	34.1%	63.7%
1A	26	28.6%	92.3%
2A	3	3.3%	95.6%
2C	4	4.4%	100%

Source: The authors (2024, p. 13)

George Winter's (1926) classification was used to describe the inclination of the third molar in relation to the second molar. The most commonly observed positions were mesioangulated (39.6%), vertical (37.4%) and horizontal (23.1%).

Discussion

In our study, 91.23% of the patients were between 18 and 35 years of age, corroborating other authors [4] who reported that 70% of the individuals who underwent panoramic radiography indicating impacted third molars were in this age group. Furthermore, according to our results, it was demonstrated that patients under 30 years of age had a significantly higher probability of having impacted or impacted third molars [7]. This correlation suggests a strong influence of age on tooth eruption. Thus, younger individuals appear to be more susceptible to this condition, possibly due to the incomplete stage of development or eruption of the teeth, which may favor the retention of third molars [7]. Furthermore, the higher prevalence of included or impacted third molars in younger patients may be associated with the fact that individuals over 35 years of age have often already undergone extraction procedures for these teeth [2].

In terms of gender distribution, 35.09% were male and 64.91% female. These data corroborate the trend observed in prevalence studies [12, 14], which associate women's greater concern with oral health [12, 14].

Regarding the distance between the third molar and the IAN, 70% of the cases were in contact, according to previous studies [3] in which approximately 89% of the cases were in contact with the IAN. Furthermore, these studies highlight that the proximity of the root of the third molar to the IAN is the main risk factor, increasing the possibility of complications by 30%. In fact, there is a three-fold increase in the probability of injury when the apex is below the IAN. The risk increases by 30% when there is direct contact between the root and the nerve [3].

Furthermore, approximately 57% of the cases presented luminal narrowing and 58.2% demonstrated absence of the mandibular canal cortex separating the tooth from the IAN. These data were not significantly addressed by previous studies and demonstrate a data gap on this anatomical characteristic. Our results revealed prevalences of 39.6% for mesioangular inclination, 37.4% for vertical inclination and 23.1% for horizontal inclination of the third molars in relation to the second molar according to the classification of Winter (1926). These data agree with previous studies [3, 11] that describe the mesioangular position as the most prevalent, followed by horizontal (23,7%) and vertical (16%) positions. Furthermore, previous studies [4] report the vertical position as the most prevalent.

The evaluation of anatomical variations revealed the presence of retromolar canal in only 4.4% of cases, without the identification of other anatomical alterations. In a literature review [17], the retromolar canal was found in 651 mandibles out of a total of 1,934 studied, corresponding to 33.6% of the total. Other authors [5] observed the occurrence of retromolar canals in 5.0% of their sample, in agreement with our results. Anatomical variations of the mandibular canal may predispose to the occurrence of surgical complications in third molar extractions [17]. Of 25 studies reviewed, with 7,044 mandibles, the main complications are exposure and damage of the inferior alveolar nerve and hemorrhages in the interforaminal region. In the postoperative period, some complications are reported such as pain, alveolar osteitis, abscesses, changes in sensitivity and bleeding, highlighting the importance of additional care in the presence of anatomical variations of the canal [17].

Quantitative analyses based on the Pell and Gregory (1933) classification revealed that position 2B was the most prevalent (34%), followed by position 1A (28%). The least prevalent positions were 2A and 2C (3% and 4%, respectively). In agreement, other authors [11] reported position 2B as the most prevalent (23%), followed by positions 1A and 2A7. Another study [4] reported that the most prevalent position was 1 and 2 respectively, while occlusal levels A and B were the most prevalent, respectively. However, controversial data demonstrated that the most prevalent position was position 1B (62 teeth, 31.3%), followed by 2B (40 teeth, 20.2%) and 1A (31 teeth, 15.7%) [3].

The evaluation of the position of the IAN in relation to the third molar revealed that the most prevalent position was inferior in relation to the tooth, while the least prevalent position was between the roots. Our results revealed an association between the IAN and the spatial position of the third molar. The most prevalent contact positions were detected when the IAN followed trajectories lingual and inferior in relation to the tooth. The lingual and inferobuccal trajectory represented the second highest prevalence in the total sample. In a literature review [8], the IAN injury rate was 17.66%

in cases in which the IAN was positioned lingual in relation to the roots of the third molar. However, the IAN injury rate reduced to 3.80% when the IAN was positioned buccal in relation to the roots of the third molar. Thus, the possibility of injury to the IAN is significantly higher when the nerve is in the lingual position in relation to the roots of the third molar [10]. In this context, most of the sample of third molars in this study presented a high risk of injury, both due to the trajectory and the prevalence of contact with the IAN.

Thus, the data obtained in this study reveal that the most frequent trajectory of the IAN in relation to the third molar was inferior, accompanied by a high percentage of direct contact between the tooth and the canal. This contact possibly promotes narrowing and discontinuity of the mandibular canal cortex, confirming a high risk of injury to the IAN. In addition, the greater prevalence of the mesioangular position of the third molars consolidates this inclination as an important factor in determining surgical risk [3, 11, 16]. These anatomical characteristics require greater attention during surgical planning, mainly due to the high susceptibility to intraoperative and postoperative complications [3].

Conclusion

The inferior trajectory of the IAN was the most common (28%), accompanied by contact with the third molar in 69% of cases. In addition, there was narrowing of the canal in 57% of the tomographies, absence of the canal cortex in 58%, and the mesioangular position of the tooth was observed in 39% of the cases. The retromolar canal was observed in 4.4% of the cases, and position 2B was the most common. A significant prevalence of contact between the third molar and IAN was observed, which increases the risk of nerve injury. These results highlight the importance of cone beam computed tomography (CBCT) in the careful evaluation of the relationship between the third molar and the mandibular canal to optimize surgical planning and minimize the occurrence of complications.

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