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Assessment of the Anterior Loop of the Mental Nerve in a Sample of Egyptian Population using CBCT: a Retrospective Study

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ABSTRACT— The Assessment of the anterior loop (AL) of the mental nerve is mandatory to avoid its injury during surgical procedures in the inter-foraminal area where its prevalence and extension varies widely among different populations. So, this research aims to fully assess the anterior loop of the mental nerve in a sample of Egyptian population using the cone beam computed tomography. In this cross-sectional retrospective study 212 CBCT of mandibular quadrants of Egyptian individuals were acquired from the database available at ORASCAN dental imaging center Located in Cairo, Egypt. 106 scans were of males and 106 scans were of females. Cranex 3DX ® SOREDEX, Finland was used in acquisition of these scans. The scans were imported to OnDemand3D ® App (Cybermed, Seoul, Korea) for image viewing and analysis. The prevalence of the AL was 59.9% in the whole sample, with a maximum length of 3.27 mm, the minimum length measured was 0.86 mm and the mean of the measurements was 1.9 mm ± 0.70. It was concluded that The AL is present with a moderate percentage in the Egyptian population; therefore, CBCT imaging should be considered for its full assessment before any surgical procedure in the inter-foraminal area specially during implant procedures to avoid its injury.

KEYWORDS: Cone-Beam Computed Tomography (CBCT), Egyptian Population, Implant Planning, Inferior Alveolar Canal

1. Introduction

Knowledge regarding the presence of the anterior loop and measuring its length is critical during implant planning and other surgical procedures to avoid its injury. Particularly concerning implantology where the exact position of the mental foramen and anterior loop identifies the most distal point for implant placement in the inter-foraminal region; to avoid any injury resultant in sensory impairment in this area [1]. Where the incidence of temporary changed sensation ranged between 8.5 to 24 % after implant placement surgery [2]. Likewise, the incidence of permanent sensory alteration to the lower lip after implant placement surgery has reported to range between 7 to 10 % [3].

The prevalence of the anterior loop has a very wide variation ranging between 0 to 94 % and an average length of 0.1 to 6.92 mm owing to the different methods of assessment used such as cadavers, 2D radiographs, 3D imaging techniques and also the different populations studied, where the race, gender, age and dental status have an effect on the results [4].

The extension of the AL of the mental nerve has not been recorded before in the Egyptian population or in the African continent in any previous study according to [5].

Cone Beam Computed Tomography (CBCT) is well-thought-out as the imaging modality of choice for implant planning and one of the reliable three-dimensional imaging modalities, that has been recently considered by dentists and oral radiologists specifically as the ultimate gold standard [4], [6- 8].

Measuring the extension of the anterior loop could be carried out using different CBCT reconstruction image types, in which a significant difference is found between the different interpretation methods [5].

The aim of this study is to assess the presence of the anterior loop and its extension in a sample of Egyptian population using two different CBCT interpretation methods with respect to the gender and side effect.

2. Materials and Methods

This is a retrospective cross-sectional study that was approved by the Ethics Committee of Scientific Research, Faculty of Dentistry, Cairo University

In this cross-sectional study, 212 CBCT images of mandible quadrants belonging to Egyptian individuals; each having both right and left quadrants examined bilaterally as part of their dental diagnosis and/or treatment planning, were acquired during a one-year period from archives of ORASCAN dental imaging center in Cairo, Egypt. Only the patient's identification numbers on the computer database were used in saving the collected data in order not to assault the patient's privacy; and the gender of the patient was identified from the patient's demographic data accessible on the patient's file on the database of the private radiographic center.

Sample size calculation:

Sample size calculation was performed using Epi Info 7.2.2.2. Based upon the results of a previous study by [9], the prevalence of the anterior loop = 23.5%. Using alpha (α) level of (5%), acceptable margin of error = 6%, the minimum estimated sample size was 192 subjects. The sample size calculation was approved by the Medical Biostatics Unit, Faculty of Dentistry, Cairo University, Cairo, Egypt.

The inclusion criteria that were taken into consideration:

1. Adult Egyptian patients both females and males of age above 18 years old.
2. CBCT scans that showed unilateral or bilateral mental foramena; with minimum 2 mm length distal to the mental foramen (mental foramen & anterior mandible are clearly delineated).

The Exclusion criteria were:

1. CBCT scans that had a poor quality or artifacts interfering with the assessment of the anterior loop of the mental nerve.
2. CBCT scans that showed any pathological lesion in the inter-foraminal area (tumour or impaction).

Matching criteria and allocation ratio:

Not applicable in the study.

Variables:

- Length of anterior loop's mesial extension if present.
- Gender of the patient was identified and addressed, as the prevalence of the anterior loop of the mental nerve and its length may show sex predilection.
- Side of the mandible.

Image acquisition and analysis:

The selected CBCT scans were all performed using the Cranex 3DX ® SOREDEX, Finland at a medium

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field of view of the scans, 8 cm wide, 6 cm height, 90 kVP, 10 mA, scan time 6 seconds and 0.2 mm voxel size. This included either both sides of the mandible in one CBCT image or both quadrants of the mandible in two CBCT images, allowing the evaluation of mental foramen and part of the IAN with a minimum of 2 mm distal to the mental foramen.

The CBCT images were then imported to OnDemand3D ® App (Cybermed, Seoul, Korea) for image viewing and analysis.

Using the 3D module, reference lines were modified to confine with the buccolingual orientation of the inferior alveolar loop, to obtain a re-oriented axial cut showing the inferior alveolar canal and mental foramen opening on the same plane. The presence or absence of the AL of the IAN was detected from modified axial cuts showing either Type I (Y shaped anatomy) or Type II (T shaped anatomy) with no AL or Type III canal (with AL) (Figure 1).

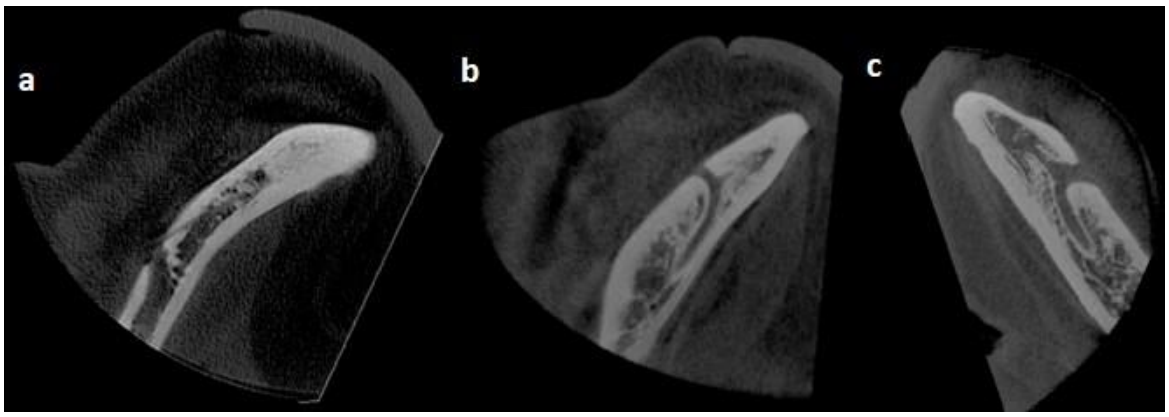

Figure 1 Modified Axial Cuts showing variants of the Inferior Alveolar Nerve: (a) Type I (Y shaped anatomy) (b) Type II (T shaped anatomy) with no Anterior Loop or (c) Type III canal with Anterior Loop

In scans with an AL on the modified axial cuts, a blue line was drawn at the most mesial point of the mental foramen, in addition to a green line drawn at the maximum extension of the anterior loop perpendicular to the outer cortex of the mandible. Then a red line was drawn to measure the distance between both lines accounting for the length of the anterior loop in millimeters (Figure 2).

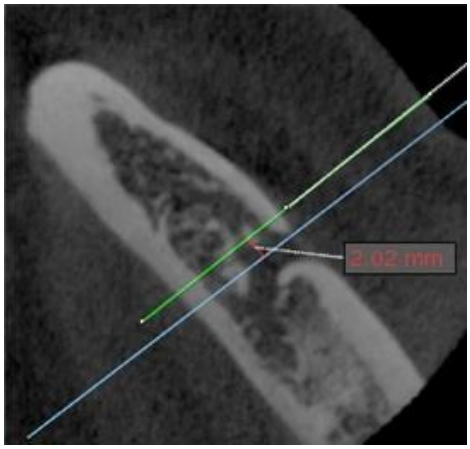

Figure 2 Measurement of the Length of the Anterior Loop on the modified axial cut

Using the DVR module; an arch line was drawn on the axial plane to get a reformatted panorama; then the

mesial extension of the AL was detected, and its length was measured by counting the number of the consecutive adjacent vertical cuts on cross-sectional view between the slice showing the anterior border of the mental foramen and the anterior border of the loop using slice interval of 0.3 mm (Slice Thickness adjusted to 0).

The measurement accuracy of the length of the AL from cross -sectional cuts was compared with the length measured on the modified axial cuts. The measurements on the axial cuts were considered the gold standard.

On the cross-sectional cuts of this mandibular quadrant, the mesial extension of the anterior loop was detected from cuts # 212 till cut # 218 in which the slice interval was set to 0.3 mm; accounting to a mesial extension for the loop of 1.8 mm (from cuts 212 to 217 = 0.3 X 6) (Figure 3).

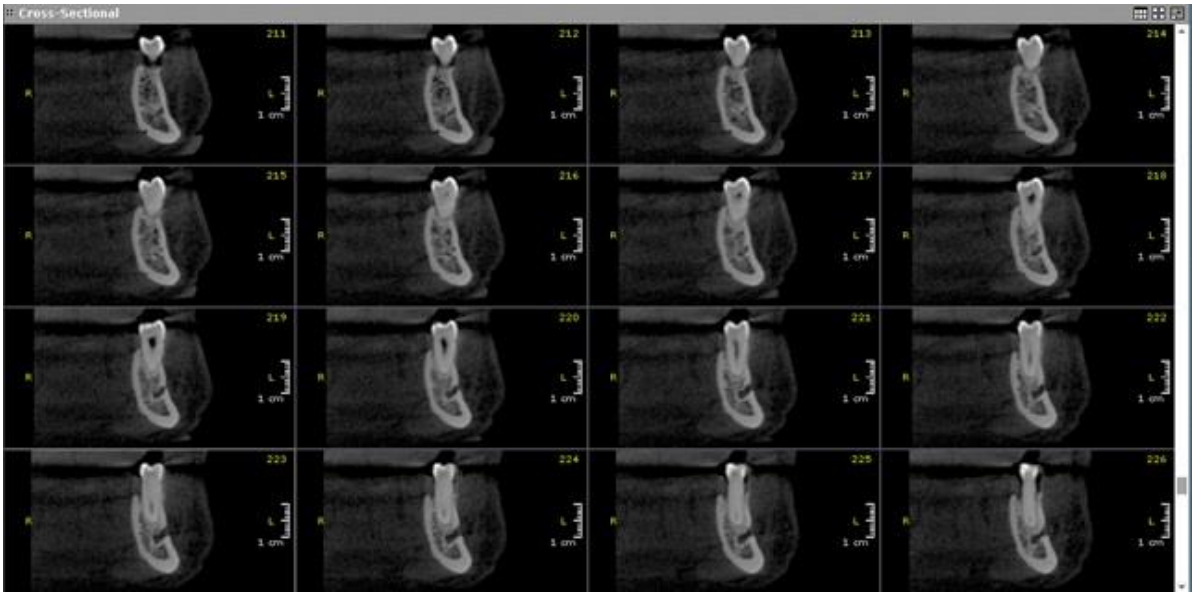

Figure 3 Assessment of the Anterior Loop's mesial extension on Cross -Sectional cuts

Each radiologist evaluated the modified axial images for detection of the anterior loop. Then the first radiologist re-evaluated the scans after two weeks. Intra-observer and inter-observer variability were evaluated. The length of the AL was measured once on the modified axial images by the first radiologist. The mesial extension of the AL on the cross- sectional cuts was interpreted by the two oral radiologists independently, then the first radiologist re-evaluated the measurements after two weeks.

Statistical analysis:

Data was analyzed using IBM SPSS statistics (Statistical Package for Social Science), version 21 (SPSS Inc., Chicago, IL). Numerical data was described as mean and standard deviation or median and range. Categorical data was described as numbers and percentages. A p-value less than or equal to 0.05 was considered statistically significant. All tests were two tailed.

Intra-observer reliability was analyzed using Cohen's kappa coefficient. Fleiss' kappa was run to determine if there was agreement between the observers' judgement (Inter-rater reliability).

ANOVA test was used to analyze the difference between the means of the three cross-sectional cuts readings. T-test was used to compare the average of the cross-sectional measurements and the axial

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measurements.

3. Results

212 CBCT images of Egyptian patients were included in this cross-sectional study with a gender predilection of 1:1 (female: 106, male: 106) each having both right and left quadrants examined bilaterally (right: 106, left: 106). Their ages ranged from 18 to 60 years.

Frequency and percentage of the anterior loop of the IAN in the whole sample (212 mandibular quadrant of both females & males) interpreted by two oral radiologists independently is 59.9% (127 CBCT images of the 212 showed an AL) as seen in (Figure 4).

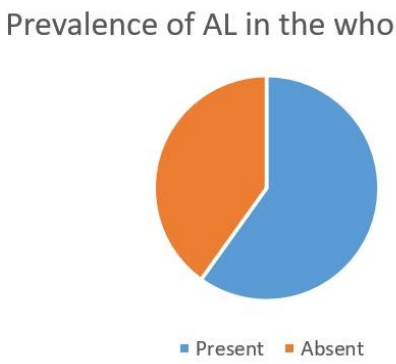

Figure 4 Prevalence of the Anterior Loop in the whole sample

Prevalence of the AL according to the gender and examined side is shown in Table 1.

Table 1: Prevalence of the Anterior Loop according to the gender and examined side.

Gender	Frequency	Percentage	Side	Frequency	Percentage
Female	64	50.4	**Left**	71	55.9
Male	63	49.6	**Right**	56	44.1
Total	127	100.0	**Total**	127	100.0

Accordingly, it was found that 96 anterior loops were observed bilaterally on both right and left sides (48 bilateral case) and 31 anterior loops were found unilaterally on either the right or left side.

Using the built-in measuring tools (axial cuts) in OnDemand 3D software "MPR module", the maximum length of the anterior loop was 3.27 mm, the minimum length measured was 0.86 mm and the mean of the measurements was 1.9 mm ± 0.70 as shown in Table 2.

Table 2: Measurements of the Anterior Loop on Axial Cuts

	N	Minimum	Maximum	Mean		Standard Deviation
					Standard Error	
Axial Measurements	127	0.86	3.27	1.9327	0.06227	0.70171

Non-parametric test used to compare the medians of both females and males on the axial measurements has

shown highly statistically significant difference between both genders, where the medians were 1.59 mm and 1.92 mm in females and males respectively (Figure 5).

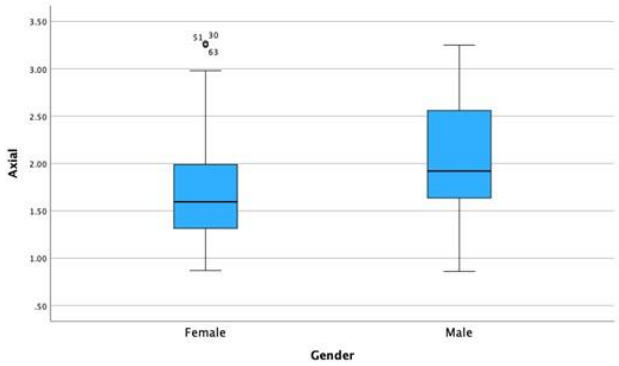

Figure 5 Box and whisker plot showing data distribution of the axial measurements according to the gender.

Regarding the side, comparison of the axial measurements on both sides (Right and Left) showed no statistically significant difference between the measurements (p = 0.539, 0.764 = > 0.05).

Using the cross- sectional cuts on OnDemand 3D software "DVR module"; there was no statistically significant difference between the means of the three readings (2 readings by the 1st observer and one reading by the 2nd observer) by using the ANOVA test.

Accordingly, from the measurements of the three readings' mean, the maximum extension of the anterior loop on the cross-sectional cuts was 3.3mm, the minimum extension was 0.9mm and the mean was 1.88 ± 0.65 (Figure 6).

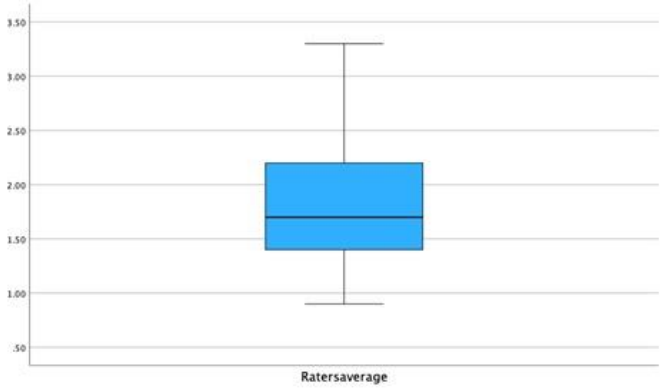

Figure 6 Box and whisker plot showing data distribution of the mean of cross-sectional readings.

Finally, when comparing the measurements of the AL using these two different measuring techniques, application of t test for two different groups showed no statistically significant difference between the means of the two groups ((p = 0.545), p >0.05) (Table 3) (Figure 7).

Table 3: Comparison Between Cross-Sectional and Axial Measurements of the Anterior Loop

Point of Comparison	Technique of Measurement	N	Mean	Standard Deviation	Standard Error

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MEASUREMENT	1.Average Cross-Sectional Measurements	127	1.9065	0.63990	0.05678
	2.Axial Measurement	127	1.8591	0.60868	0.05401

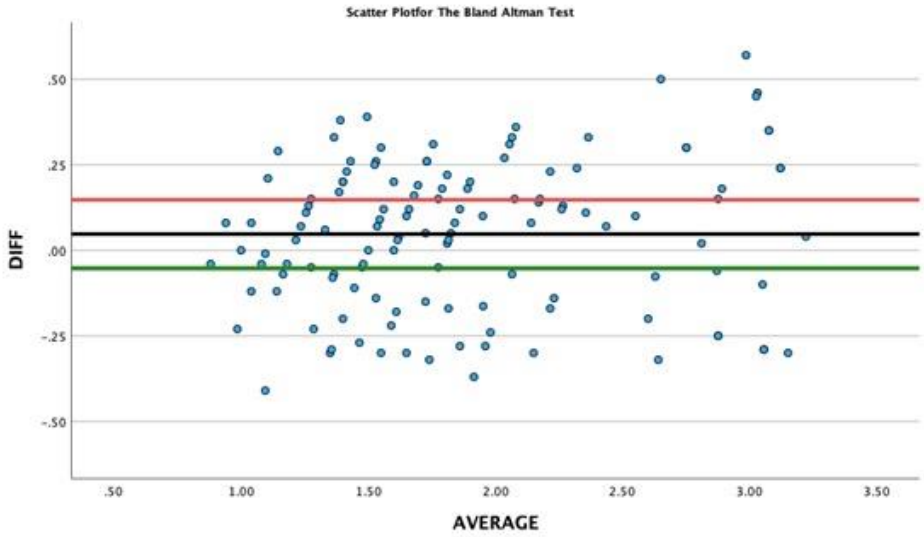

Figure 7 Bland Altman Plot showing no grouping of measurements to one side of the mean difference.

4. Discussion

The number of included males and females; and the number of right and left mandibular quadrants included were equal to externally validate the results related to the gender and side effects in the Egyptian population.

Regarding, the technique used for AL's interpretation, modified axial images were created, where the most posterior and anterior margins of the mental foramen with the path of the IAN and its emergence from the mental foramen could be visualized on one plane, and the presence or absence of an AL could be recorded as previously demonstrated by [10], [11].

A full assessment of the AL was done by measuring its length if present. First the measurements were taken on the modified axial images by scrolling through the cuts and measuring at a level were the most anterior point of the AL was observed; the rationale behind choosing this specific technique as a primary measuring gold standard method was that the modified axial images offer an accurate presentation of the structure needed to be measured since that the whole anatomical structure from its start to end points with its bucco-lingual coarse could be visualized on a single cut; and as concluded by [11] who compared the measurements of the AL's length on cadaveric specimens to measurements on CBCT images of the modified axial plane that those CBCT images offered a highly precise and reliable imaging modality to be used in assessing the AL for its presence or absence and also its exact length.

Following this, a second measurement of the mesial extension of the AL was recorded on cross- sectional cuts; this technique was previously used by [12- 14].

In this technique, when two round hypodense areas were spotted in a slice it was counted as a mesial extension of the AL; where the inferior round area is considered the mandibular canal that passes anteriorly through the mandible and the superior round area is the part of the mental nerve that loops backwards to

exit the mental foramen subsequently the number of slices with this presentation is multiplied by the slice interval [13].

A slice interval of 0.3 mm was chosen in order to minimize the chance of missed data due to partial inclusion of endpoints within the first and last cross-sectional slices [12].

In the current study, the two chosen CBCT interpretation techniques were the one that gives the most accurate measurements which is measuring on the modified axial plane and the most used technique in implant planning which is measuring on the cross-sectional cuts; and the results of both techniques were compared to each other [11], [15].

Regarding the effect of the examined side, in the current study AL was prevalent bilaterally in 75.6% of the cases and unilaterally in 24.4% of the cases. These results are closely consistent with the results of [11] on Iranian population that had the same AL prevalence as our study; in which the prevalence of bilateral ALs was higher compared to unilateral ALs with 65.5% compared to 34.5% unilateral AL. In addition to other studies that had this same finding including [6], [14], 16- 18].

Other studies documented opposing results; in which the unilateral AL prevalence was recorded to be more than the bilateral AL prevalence as mentioned in the studies conducted by [19- 23].

With a prevalence of 56% on the left side compared to a prevalence of 44 % on the right side showing an effect of the observed side on the prevalence of the AL. The following studies' outcome were the same as our study regarding the predominance of the left unilateral AL: [19], [24], [25] opposing the results of [1], [7], [26], [27] were they observed more prevalence on the right side.

Regarding the gender effect on the prevalence of the AL; in the current study the prevalence recorded was 49.6% in males and 50.4% in females showing no difference between the two groups.

As for the measurements of the AL's length on the modified axial cuts the minimum length measured was 0.86 mm, the maximum length measured was 3.27 mm with a mean length of 1.9 mm ± 0.7, putting into consideration that 33.9% of the ALs' measurements in the Egyptian population was above the recommended safety margin of 2 mm to be left away from the AL during implant planning by [5].

The mean length recorded in females was 1.73 mm 95% CI (1.5911-1.8873) and the mean length in males was 2.07 mm 95% CI (1.9319-2.2391). As for the medians of these measurements, there was a statistically significant difference between the medians of males and females. The results of this current study was similar to those results of the study conducted on a Brazilian population, Indian Population and a southern Chinese population were the AL showed a greater average length in males compared to females [17], [18], [21].

However, it was mentioned that no significant difference was observed according to gender effect on the AL's length. [5].

Following the AL's measurement on the modified axial plane; the measurements were repeated on the cross-sectional cuts twice by the first observer and once by the second observer and the average of the three readings was calculated, where the average of measurements of the cross-sectional readings was 1.859 mm ± 0.6, this finding is approximately close to the mean AL length calculated in a subgroup meta-analysis of

9 studies measuring the length of the AL on cross-sectional cuts were the mean length of the 9 studies was 1.927 mm [5].

Finally, a comparison was made between the AL's measurements on the modified axial plane and the average of measurements from the cross-sectional cuts and there was no significant difference between both readings' technique; owing this to using a slice thickness of zero in our study and a slice interval of 0.3, thus minimizing the chance of losing data when scrolling through the cross-sectional cuts and interpreting the extension of the AL as accurate as possible on the DVR module. The slice thickness of zero used in the current study was different than other studies that used a thicker slice such as [28], [24], explaining the non-significant difference between the results of both interpretation methods in our study [29].

5. Conclusion

CBCT offers accurate detection and measurements of the AL using different interpretation methods.
This anatomical variation must be evaluated appropriately during implant planning since its prevalence is not low in Egyptian population and varies widely between different ethnicities and populations.

6. Conflict of Interest

The authors didn't receive any type of financial support for this work from any organization or foundation, so they declare that they have no conflict of interest.

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