ORIGINAL PAPER

THE EFFECT OF WINTER'S RED LINE, ANGLE OF IMPACTION, AND RADIO-MORPHOMETRIC INDICES ON SURGICAL DIFFICULTY OF IMPACTED MANDIBULAR THIRD MOLAR: A PROSPECTIVE OBSERVATIONAL STUDY

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ABSTRACT

Introduction: The most common oral and maxillofacial surgical procedure is the surgical extraction of impacted third molar in the mandible. Predicting third molar difficulty depends on various clinical, anatomical, and radiographic variables.

Objectives: The purpose of this study was to correlate the Winter's red line, angle of impaction, and bone density (gonial and antegonial indices) with surgical difficulty.

Material and methods: This prospective observational study included 55 patients, who had undergone surgery for removing impacted lower third molars under local anesthetic. Independent (predictor) variables were pre-operative measurement of Winter's red line in millimeters, angle of impaction in degrees, and bone density evaluated with two radio-morphic indices, i.e., gonial and antegonial, both measured in millimeters. Dependent (outcome) variables included surgical difficulty determined by surgical technique and operation time.

Results: Regarding the red line and angle of impaction, there was a strong positive correlation between them with duration of surgery. With respect to density indices, there was a weak correlation between gonial and antegonial indices with duration of surgery. All variables were associated with an increased difficulty determined by surgical technique.

Conclusions: The Winter's red line and angle of impaction have a strong influence on determining the difficulty of impacted mandibular third molar's surgery, while the gonial and antegonial indices are not clinically relevant to determine the surgical difficulty.

Key words: third, molar, duration of surgery, index.

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INTRODUCTION

The most common intervention in oral and maxillofacial surgery is the surgical extraction of impacted teeth. However, many complications are associated with this procedure and in order to avoid them, proper clinical and radiographic assessments are mandatory before third molar surgery [1]. To determine the difficulty of extracting mandibular third molars, Winter used three lines: white, amber, and red. The red line represents the depth of impaction that is drawn perpendicularly from the amber line to the anticipated point of application at the cemento-enamel junction of third molar. It indicates the amount of bone that needs to be removed before the elevation of the tooth [2].

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It was suggested that with each millimeter increase in the red line measurement, surgical difficulty will increase three times, with a greater risk of inferior alveolar nerve injury [2]. Few clinical studies have investigated the effect of Winter's red line as an indicator of the depth of impaction [3-5] on the extraction difficulty of impacted teeth, as many studies used the position of impaction as per Pell and Gregory classification [6-12].

Zhang *et al.* [13] proposed an index that included the angle of impaction as a factor to assess the surgical difficulty among Asian population. This was determined by drawing lines from the cemento-enamel junction of third molar to the contact point between the second and third molars, and then along the lamina dura of lower second molar. The authors found that the difficulty of extraction increases when the angle is 30 degrees or more [13].

One of the factors that may influence the difficulty of removing impacted teeth is bone density [14]. Bone density can be measured using computed tomography (CT) or cone beam CT, but these methods are associated with high doses of radiation compared with panoramic radiographs [14]. Various radio-morphometric indices are used to quantify the density of mandible with panoramic radiographs, such as the gonial index and antegonial index. These indices are used to assess mandibular cortical shape and width, either qualitatively or quantitatively, and together with other criteria, such as symptoms and family history, can be used to assess osteoporosis risk [15]. There are no previous clinical studies that addressed the effect of radio-morphometric indices on the difficulty of extraction of impacted mandibular third molars.

OBJECTIVES

The aim of this study was to assess how the Winter's red line, angle of impaction, and gonial and antegonial indices of bone density affect the surgical difficulty of impacted mandibular third molars, assessed by duration of surgery and surgical technique.

MATERIAL AND METHODS

This prospective observational study was done between December 2021 and June 2022 at the University of Baghdad, College of Dentistry, Department of Oral and Maxillofacial Surgery. Every patient signed an informed consent to participate in this research after Institutional Research Ethics Committee accepted the study's protocol (approval No.: 418121). The study was registered at clinicaltrials.gov (NCT05320744), and was guided by STROBE guidelines. The study involved 55 patients, who had undergone extractions of impacted mandibular third molars surgically under local anesthetic. There were 26 female and 29 male patients, with age ranging from 18 to 38 years old.

Inclusion criteria were healthy adult patients of at least 18 years old of both gender, who met the American Society of Anesthesiologists physical status classification level I (ASA I) and level II (ASA II), and presented with mesio-angular or horizontal impacted mandibular third molars. Patients with vertically and disto-angularly impacted teeth, those with uncontrolled systemic diseases, pregnant women, patients with an acute infection at the side of surgery at the time of procedure, those with cysts or tumors associated with impacted teeth, and patients who were missing second molars at the side of surgery, were all excluded. Similarly, patients with impacted teeth with unfavorable root morphology, such as dilacerations (which may increase difficulty of extraction), impacted teeth that demonstrated signs of close contact with the inferior alveolar canal in panoramic radiographs, such as darkening and deflection of the root and diversion of inferior alveolar canal, since such involvement may increase the duration of surgery and hence the degree of difficulty, were also excluded. Recurrent pericoronitis, orthodontic treatment planning, caries involving the impacted teeth and/or nearby mandibular second molars, and periodontal diseases were among the reasons for extracting mandibular impacted third molars.

A pre-operative panoramic radiograph was obtained for each patient with panoramic Planmeca ProOne®, Helsinki, Finland, with specifications: 66 KV, 9 mA, 14.9 S, and 97 mGy × cm^2, and using Planmeca Romexis Viewer to measure the Winter's red line, angle of impaction, gonial index, and antegonial index. Radiographic evaluation included checking the angulation, position, and depth of impaction, assessment of root formation and morphology, any pathological condition related to the surgical area, and relation between the impacted mandibular third molar and the inferior alveolar canal.

Surgical procedures were all performed under local anesthesia using lidocaine 2% with adrenaline 1 : 100,000 by one operator, who provided an inferior alveolar nerve block. Patients were instructed to rinse with 0.12% chlorhexidine mouthwash for 30-60 seconds before surgery. After achieving anesthesia, a full-thickness (muco-periosteal) buccal flap was reflected subperiosteally, and then the bone was removed buccally (bone guttering) with or without tooth sectioning, using a surgical handpiece and bur under copious irrigation with sterile normal saline. When the extraction was done by using an elevator only, the difficulty was considered low; when it required bone removal, the difficulty was considered moderate; when it required bone removal and tooth sectioning, the difficulty was considered high [16]. Duration of surgery was measured in minutes from the first incision to the last suture.

Independent (predictor) variables were pre-operative measurement of Winter's red line in millimeters that was drawn perpendicular from the amber line to the anticipated point of application at the cemento-enamel junction of third molar from the amber line perpendicularly to the point of application of dental elevator in

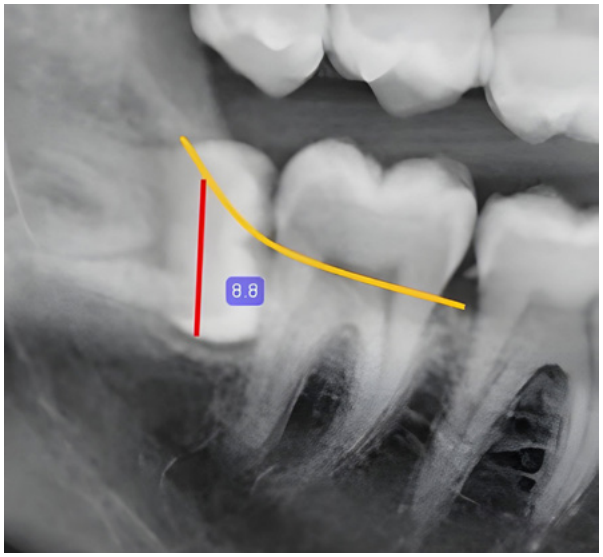

FIGURE 1. Winter's red line measurement in millimeters from the amber line perpendicularly to the point of application of dental elevator in the cemento-enamel junction of third molar

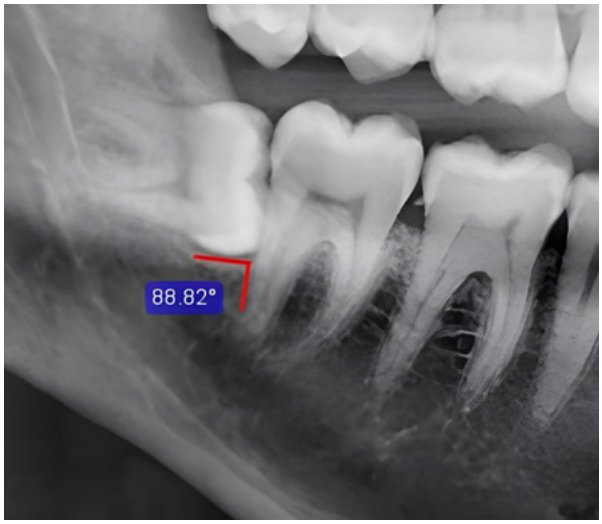

FIGURE 2. Angle of impaction measurement in degrees by drawing lines from the cemento-enamel junction of third molar to the contact point between the second and third molars, and then along the lamina dura of lower second molar

the cemento-enamel junction of third molar (Figure 1). The angle of impaction was measured in degrees by drawing lines from the cemento-enamel junction of third molar to the contact point between the second and third molars, and then along the lamina dura of lower second molar (Figure 2). Bone density was represented by two radio-morphic indices, such as gonial and antegonial indices. The gonial index was determined by measuring the mandibular cortical thickness in millimeters in the angle region at the intersection between the posterior border of mandibular ramus and the lower border of mandible. The antegonial index was determined by measuring the mandibular cortical thickness in millimeters at the intersection of vertical line along the anterior border of ramus and horizontal line along the lower border of mandible (Figure 3). Dependent (outcome) variables included the surgical difficulty that was determined by the duration of surgery, and surgical technique.

For statistical analysis, GraphPad Prism version 9 for Windows was applied. Frequency and percentage of categorical variables as well as mean and standard deviation (SD) of numerical variables were calculated as part of descriptive statistical analysis. Shapiro-Wilk normality test, ANOVA test, Spearman and Pearson correlation tests, and Kruskal-Wallis test were all used in inferential analyses. Probability values under 0.05 were deemed statistically significant.

RESULTS

The present study included 55 patients with impacted mandibular third teeth. The mean (SD) age of patients was 24.78 years (4.66), with age range of 18-38 years.

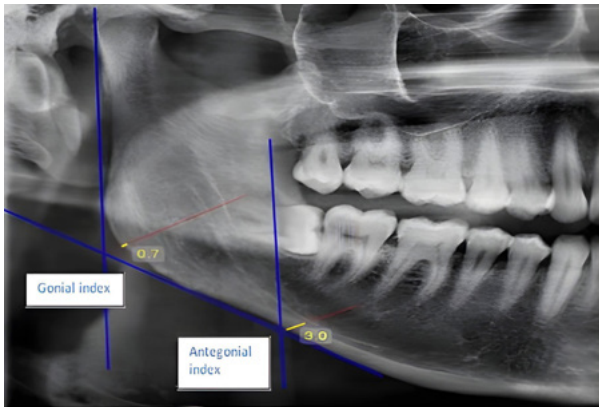

FIGURE 3. Gonial and antegonial indices measurement (gonial index was determined by measuring the mandibular cortical thickness in millimeters in the angle region at the intersection between the posterior border of mandibular ramus and the lower border of mandible, while antegonial index was determined by measuring the mandibular cortical thickness in millimeters in the intersection of vertical line along the anterior border of ramus and horizontal line along the lower border of mandible)

The study group consisted of 29 (52.7%) males and 26 (47.3%) females. According to the angulation, 29 (52.7%) patients had mesio-angularly impacted teeth, whereas 26 (47.3%) patients had horizontally impacted teeth. Descriptive statistics of the study variables are summarized in Table 1.

Table 2 shows the correlation between the predictor variables and the duration of surgery, and it indicates that an increased red line, angle of impaction, and antegonial index resulted in an increased duration of extraction,

TABLE 1. Descriptive statistics of study variables

Variables	Minimum	Maximum	Mean ± SD
Red line (mm)	2.0	8.9	5.39 ± 2.124
Angle of impaction (degree)	19.86	88.96	60.80 ± 21.87
Gonial index (mm)	0.5	1.5	0.86 ± 0.21
Antegonial index (mm)	1.5	5.4	3.03 ± 0.73
Duration of surgery (minutes)	5.0	45.0	21.24 ± 12.54

SD – standard deviation, mm – millimeter

TABLE 2. Correlation of predictor variables with duration of extraction

Correlation	Duration of extraction (min) vs. red line (mm)	Duration of extraction (min) vs. angle of impaction (degree)	Duration of extraction (min) vs. gonial index (mm)	Duration of extraction (min) vs. antegonial index (mm)
r-value	0.9551*	0.8039*	–0.3555*	0.3844†
p-value	< 0.0001	< 0.0001	0.0077	0.0038

**Spearman correlation*
†Pearson correlation

TABLE 3. Relationship of predictor variables with technique of extraction

Variables	Technique of extraction			*p*-value
	Low/mean ± SD	Moderate/mean ± SD	High/mean ± SD	
Winter's red line (mm)	2.96 ± 0.61	4.73 ± 0.91	7.02 ± 1.33	< 0.0001*
Angle of impaction (degree)	36.54 ± 10.24	48.94 ± 6.45	78.71 ± 10.77	< 0.0001*
Gonial index (mm)	0.98 ± 0.27	0.83 ± 0.14	0.80 ± 0.17	0.0201*
Antegonial index (mm)	2.62 ± 0.58	3.16 ± 0.44	3.24 ± 0.79	0.0152†

SD – standard deviation
**Kruskal-Wallis test, †ANOVA test*

and a decreased gonial index resulted in an increased duration of extraction. According to the technique of extraction, most of the cases (52.7%) were categorized as having high difficulty, followed by low (30.9%) and moderate (16.4%) difficulty categories. Table 3 presents the relationship between the predictor variables and the technique of surgery. All these variables were associated with an increased difficulty determined by the surgical technique.

Apart from the post-operative inflammatory sequelae, including pain, swelling, and trismus, which were reported by the patients, no post-operative problems in this study, such as infection, dry socket, or neurological damage were observed.

DISCUSSION

In order to predict surgical difficulty and complications, an adequate assessment must be performed, with appropriate treatment plan and communication with the patient throughout the surgical procedure. The current study evaluated the effects of Winter's red line, angle of impaction, and bone density (gonial and antegonial indices) on the surgical difficulty measured by the duration of extraction and surgical technique. The mean age of the participants in this study (24.78 years) was comparable with that of other studies (range, 23.6-26.16 years) [17-20]. Third molar eruption times vary by ethnic group, and it was shown that Africans' third molar eruption times are earlier than those of Caucasians and Asians [21, 22].

This study demonstrates that the Winter's red line can serve as a reliable indicator of the surgical difficulty. The depth of impaction was represented in the literature as the red line according to Winter, or by the positional category according to Pell and Gregory classification. However, Almendros-Marqués *et al.* [23] found that Pell and Gregory classification lacks reproducibility because depth B of third molars is often confused with teeth in positions A or C. An increased depth of impaction will increase the amount of bone that covers the tooth, and hence, the tooth will become less accessible and more difficult for extraction [24]. Juodzbalys and Daugela [25] reported that the coronal position of impacted tooth should be assessed from the alveolar crest rather than the occlusal plane as per Pell and Gregory classification,

because if the crown of third molar is small in size, it will locate below the occlusal plane; therefore, the difficulty of extraction is determined predominantly by the depth of impaction in the bone.

In the study, there was a positive correlation between the angle of impaction and the surgical difficulty measured by technique and duration of surgery. This may be explained by the fact that the difficulty of procedure is increased by the increased difficulty of accessing the impacted tooth due to the increased angle of impaction and increased contact surface between the second and third molars, which require more bone removal and tooth sectioning, and prolong the duration of surgery. This finding is in agreement with Zhang *et al.* [13], who studied the angle of impaction among other factors in 203 patients, and identified a cut-off angle of 30°, where impacted third molars with an angle of < 30° were considered less difficult for extraction than impacted teeth with an angle of ≥ 30°, and concluded that the angle of impaction can be used to predict third molar extraction's difficulty.

In the current study, there was an inverse relationship between the gonial index and the surgical difficulty, which can be explained by the fact that when the third molar occupies more osseous space, it weakens the bone at the angle of the mandible, resulting in a decreased gonial index. The normal value of gonial index in healthy patients was reported to be more than 1.2 mm [15]. Kazim and Fattah [26] suggested that the mandibular cortical thickness in the angle region was influenced by the presence and eruption status of the third molar, thus cases with mandibular third molar agenesis had higher index (mean, 2.13 mm) compared with cases with erupted and impacted third molars.

The relationship between the increased depth of impacted mandibular third molars and the decreased value of gonial index was linked to the increased possibility of mandibular angle fracture in patients with impacted teeth in some studies [26, 27].

This study demonstrated a weak positive relationship between the antegonial index and the surgical difficulty that is in line with previous studies, which observed that the antegonial index is a non-reliable indicator to detect low bone density, because it is affected by dental health, with lower values in edentulous patients compared with fully dentulous patients, who had higher values [28, 29]. The normal value of antegonial index in healthy patients should be more than 3.2 mm [15], and this is related to the fact that tooth extraction will impact masticatory function that will reduce osteogenesis. According to Dutra *et al.* [30], methodological issues can arise when measuring this index, particularly when determining the location of line that best fits the inferior border of the ramus of the mandible, and runs down to the lower border of the mandible. Additionally, they reported that this index is influenced by patient age, and its value declines with aging. The mean age in their study was higher than that reported in our study. Also, all the subjects enrolled in the current study were in good health and free from any metabolic conditions that could have impacted the bone structure. To the best of our knowledge, there are no studies that investigated the effect of gonial and antegonial indices on the difficulty of extraction of impacted mandibular third molars.

LIMITATIONS

The results of the current study need to be interpreted after considering its main limitations, which are related to the small sample size that may decrease generalizability of the results obtained. Also, the study included only two types of angulation (mesio-angular and horizontal), and excluded class III and position C of Pell and Gregory classification.

CONCLUSIONS

Taking into account the study's limitations, the Winter's red line and the angle of impaction have a strong influence in determining the surgical difficulty of impacted mandibular third molar, while the gonial and antegonial indices are not clinically relevant to determine the surgical difficulty.

CONFLICT OF INTERESTS

The authors declare no potential conflicts of interest concerning the research, authorship, and/ or publication of this article.

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