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RESEARCH

Clinical evaluation of the effects of radiographic distortion on the position and classification of mandibular third molars

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Objective: Panoramic radiographs are routinely employed for surgical planning of unerupted third molars. The objective of this study was to evaluate distortions in the position of mandibular third molars on panoramic radiographs.
Material and methods: Panoramic radiographs of 14 patients with indication for extraction of the mandibular third molars were used. Transurgical impressions of the crowns of the teeth to be extracted and adjacent second molars ($n = 19$) were achieved with addition silicone and poured with type IV plaster for comparison of the inclinations of the third molars on the radiographs and study casts.
Results: There was a mean difference of $-5.37°$ between the position of the third molar on the panoramic radiograph and on the study cast (standard deviation 1.46, $P < 0.05$, Student's *t*-test).
Conclusion: There is distortion in the position of teeth on the panoramic radiograph, which may influence the surgical planning; however, this does not invalidate it as the main tool for diagnosis and surgical planning of mandibular third molars.
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Keywords: radiography, panoramic; image distortion; impacted tooth; third molars

Introduction

The literature on maxillofacial surgery advocates the use of a panoramic radiograph for surgical planning of unerupted teeth.[1,2] However, the dentist must be aware of the limitations related to the process of image formation of this radiograph, which can give rise to problems such as poor detail, formation of ghost images, and especially distortions in the size and position of the objects imaged.[3–5] These distortions are caused because the panoramic radiograph projects a tridimensional surface into a bidimensional image.[3–5]

Therefore, maxillofacial surgeons must be aware of the processes involved in image formation in the panoramic radiograph, so that they may evaluate the morphology and calculate the position of the object under study and its relationships with the adjacent structures in a more precise manner.

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Material and methods

The present study was undertaken after approval by the Research Ethics Committee of this school and all subjects gave informed consent. Fourteen patients attending the Surgery Clinic of Bauru Dental School, University of São Paulo for extraction of the mandibular third molars were selected to participate. Those presenting with teeth classified as transalveolar or inverted according to Winter's classification or that could not be classified as pattern I-A according to Pell and Gregory were excluded from the sample.[1,6,7]

The radiographs of all patients were made with a Rotograph Plus® machine (Villa Sistemi Medicalli®, Italy) and automatically developed. The time interval between the making of the panoramic radiograph and accomplishment of surgery did not exceed 1 month in any case.

At the day of surgery, an impression of the surgical area was taken with addition silicone putty impression (Splash®; IvoclarVivadent, Amhearst, NY) (Figure 1), after which it was placed in a container of disinfecting solution. After antisepsis and inferior alveolar nerve block, an incision was made from the distal aspect of the

Figure 1 Initial impression before surgery

mandibular second molar through the ascending mandibular ramus, with an intrasulcular incision contouring the buccal aspect of the second molar and an oblique incision on the papilla distal to the mandibular first molar and buccal sulcus. This incision aimed at allowing better observation of the surgical area, to facilitate achievement of the second impression after exposure of the crown of the third molar. Ostectomy for exposure of the crown of the third molar was performed with long carbide burs no. 6 at high-speed under thorough water cooling. Afterwards, a gauze soaked in saline solution was placed on the area while the first impression was rinsed with saline solution for complete removal of the disinfecting chemical.

The second impression was achieved by application of a new bulk of soft addition silicone, with good flow, over the crown of the tooth and the first impression, which was then carried to its position in the mouth (Figure 2).

After curing of the addition silicone, the impression was thoroughly rinsed with saline solution and once again immersed in disinfecting solution for 24 h.

After extraction of the third molar, the surgical wound was checked and irrigated with saline solution and the flap was sutured.

Following the protocols established by the Discipline of Surgery of FOB-USP for patients submitted to oral surgery involving ostectomy, all patients were prescribed amoxicillin 500 mg every 8 h for 5 days, nimesulide 100 mg every 12 h for 3 days, and analgesic drops if required. The patients were informed about the post-operative care both orally and in writing. The suture was removed 1 week after surgery. There were no post-operative complications in these patients, nor any sign of infection or alveolitis.

At the day after surgery, the impression was removed from the disinfecting solution, rinsed with water and poured with type IV plaster for achievement of a study cast (Figure 3), which was then labelled with the patient's name and date of surgery.

The relationship between the second and third molar on the panoramic radiograph was determined by first tracing those teeth on acetate paper fixed to the radiograph and then drawing three lines on each tooth: (1) through the cementoenamel junction in a mesiodistal direction; (2) through the point of greatest convexity of the crown in a mesiodistal direction; and (3) through the midpoints of the other two lines (Figure 4), corresponding to the long axis of the tooth. With the aid of a set square and a protractor, the inclination of the third molar was measured

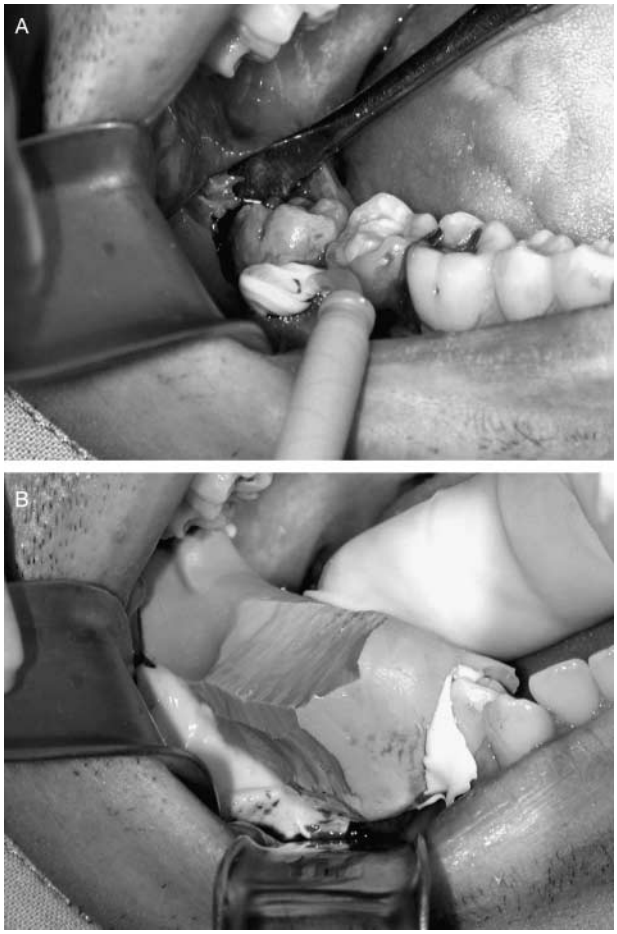

Figure 2 Second impression after exposure of the crown of the third molar

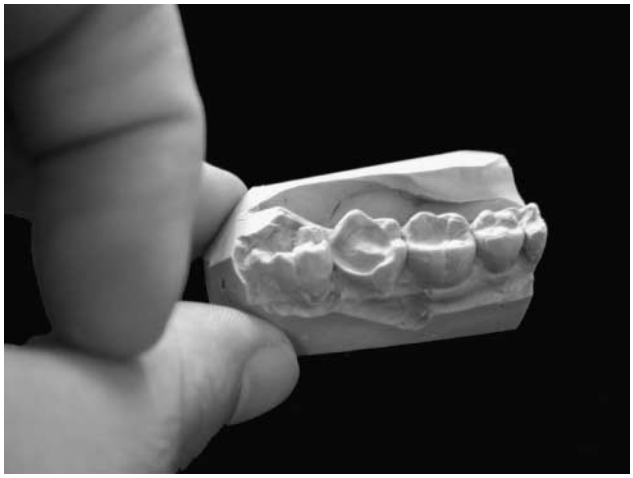

Figure 3 Study cast poured with type IV plaster

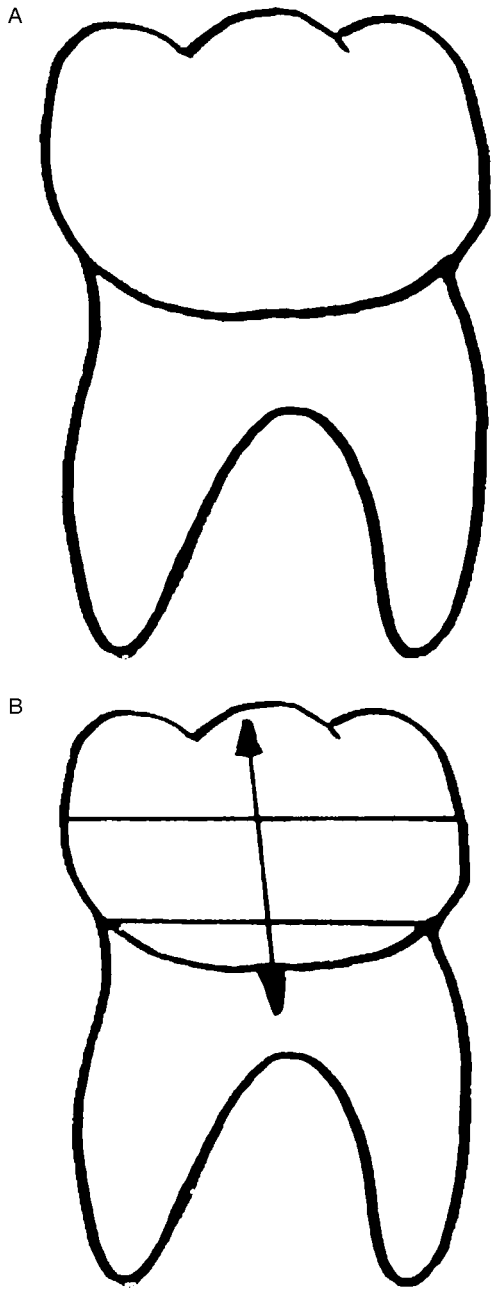

Figure 4 Method of tracing for establishment of the long axes of teeth

and it was classified as distoangular, vertical, mesioangular or horizontal, according to the criteria shown in Table 1.

Three lines were also traced on the study casts for delineation of the long axes of the second and third molars.

Table 1 Angular values adopted for classification of the mandibular third molars according to Winter[6]

Angular values	*Classification*
$-30°$ to $-5°$	Distoangular
$-5°$ to $5°$	Vertical
$5°$ to $55°$	Mesioangular
$55°$ to $105°$	Horizontal

Similarly to the panoramic radiograph, the first line was traced through the cementoenamel junction, the second through the point of greatest convexity of the crown, and the third through the mid points of the other two lines.

The inclination of the third molar was determined with use of a device designed for measurement on the study casts. This device was fabricated with clear acrylic resin and comprised an L-shaped fixed bar, on which two screws were placed on the long axis of the second molar. A vertical bar parallel to the L-shaped bar was moved along the latter and contained a base on which the other screw and a protractor were placed. This base was moved along the vertical bar and protractor and was allowed to perform a circular movement, with the screw at its centre (Figure 5).

A comparison was made for the values of third molar inclination and classification between the panoramic radiograph and study casts.

Results

Since this study employed a new methodology for measurement of the inclinations and angular distortions on panoramic radiographs, establishment of a proper sample size before onset of the investigation was difficult. Thus, the statistician of FOB-USP suggested accomplishment of at least 20 surgeries, followed by statistical analysis of these data. Since one case was lost because of fracture of the study cast upon removal from the impression, analysis was performed of 19 operations carried out on 14 patients (5 bilateral operations).

From the 19 extracted third molars, one was radiographically classified as horizontal, seven displayed mesial angulation, seven were vertical and four exhibited distal angulation, following the parameters suggested in the literature.[8,9] On the study cast one was classified as horizontal, five with mesial angulation, five were vertical and eight displayed distal angulation (Figure 6).

There was variation in all measurements of the angles formed by inclination of the third molars on the panoramic

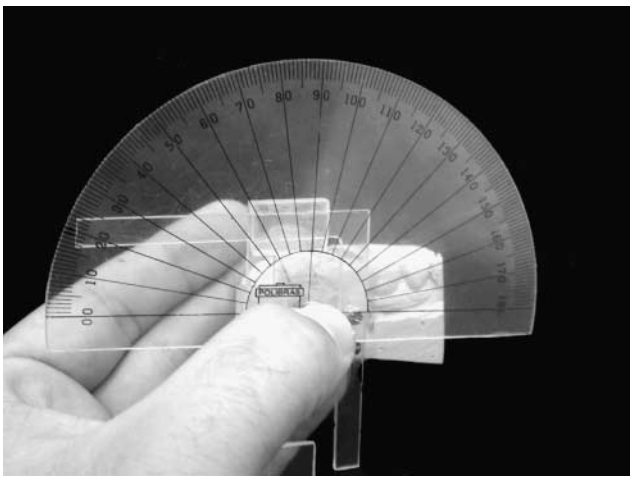

Figure 5 Device placed for measurement of the inclination of the third molar in relation to the adjacent second molar

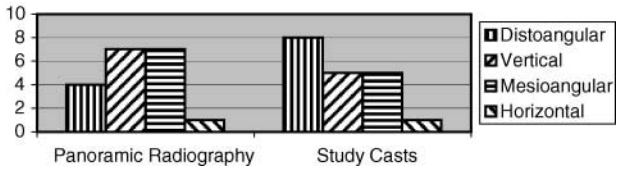

Figure 6 Comparison between the prevalence of positions of the mandibular third molar on panoramic radiographs and study casts

radiographs and on the study casts. In six cases (31.5%), this variation was enough to change the classification of the tooth clinically (Table 2).

This change in classification was bilateral in only one patient who had both mandibular third molars extracted, yet the amount of variation was not the same (5° and 9°). Variation was observed in a further three cases of patients submitted to two operations, yet affecting the classification of only one third molar. In another patient, surgery was unilateral. In a patient submitted to two operations, there was bilateral change of the measurements, which were the same (6° for the left and right sides), but classification of the tooth was maintained.

A mean variation of 5.37° was observed in the angular measurements measured on the panoramic radiographs and study casts, with standard deviation of 1.46°, maximum value of 9° and minimum value of 4°.

There was no difference in the degree of distortion between the right and left sides of the radiographs. The three largest distortions (9°, 8° and 7°) were observed at the right side of patients; however, the mean distortions for the right and left sides were similar, with mean variations in the measurements of 5.81° for the right side and 5.62° for the left side.

Statistical analysis

Basic statistical calculations, namely means and standard deviations, were performed only for the differences in the measurements of inclination of the third molars on the panoramic radiographs compared with the measurements recorded on the study casts. Since there was no standardization in the classification of extracted teeth, the means and standard deviations of the actual measurements themselves obtained from the radiographs and study casts would be meaningless.

The key was to assess whether there were any differences in measurements from the radiographs and study casts. For that reason, the Student's *t*-test for two paired samples was employed, based on the assumption that measurements of angles formed between the mandibular second and third molars on panoramic radiographs will always be different from those observed on study casts. A *P*-value of 0.001 was observed in the tests, which revealed the significance of the assumption that angular measurements in panoramic radiographs are different from angular measurements obtained on study casts.

The Pearson correlation coefficient was close to 1 (0.99819), indicating a positive correlation of the measurements from the study casts compared with the measurements obtained on panoramic radiographs.

Discussion

Utilization of panoramic radiographs as one of the main complementary examinations for most dental specialties, especially for surgical planning of third molars, has encouraged the interest for investigation of distortions in the radiographic image.

Inclination of the third molar in relation to the adjacent second molar is very important for planning of tooth extractions, since it may indicate the need (or not) for tooth sectioning, which might lead to an increase in surgical time and consequently in the trauma yielded by surgery. In these situations, utilization of more refined techniques and a higher degree of experience of the surgeon are required.

Table 2 Winter's classification of the extracted teeth on study casts and panoramic radiographs

Patients (extr. tooth)	*Radiographic measure*[a]	*Radiographic classification*	*Models measure*[a]	*Models classification*	*Variation*
(38)	14	Mesioangular	10	Mesioangular	−4
(48)	**8**	**Mesioangular**	**3**	**Vertical**	**−5**
(48)	51	Mesioangular	44	Mesioangular	−7
(38)	62	Horizontal	57	Horizontal	−5
(48)	−21	Distoangular	−25	Distoangular	−4
(38)	**−5**	**Vertical**	**−11**	**Distoangular**	**−6**
(38)	45	Mesioangular	41	Mesioangular	−4
(48)	−8	Distoangular	−12	Distoangular	−4
(48)	−19	Distoangular	−25	Distoangular	−6
(38)	4	Vertical	−2	Vertical	−6
(38)	**−5**	**Vertical**	**−10**	**Distoangular**	**−5**
(48)	**11**	**Mesioangular**	**2**	**Vertical**	**−9**
(48)	36	Mesioangular	30	Mesioangular	−6
(48)	25	Mesioangular	17	Mesioangular	−8
(48)	−10	Distoangular	−16	Distoangular	−6
(38)	**−5**	**Vertical**	**−11**	**Distoangular**	**−6**
(48)	5	Vertical	1	Vertical	−4
(38)	**−3**	**Vertical**	**−7**	**Distoangular**	**−4**
(48)	1	Vertical	−4	Vertical	−5

Lines in grey demonstrate changes in the classification of teeth according to the parameters of angular values adopted
[a]Angle between second and third molar in degrees

The results of this study demonstrated that there is a mean alteration of approximately 5° when measurements taken on panoramic radiographs are compared with those achieved on study casts obtained from transurgical impressions. With these results, it may also be stated that there is uniformity in these variations, demonstrating that the panoramic radiograph tends to exhibit a more mesial position of the third molars.

Considering that angular distortions originate by associations of vertical and horizontal distortions, and that horizontal distortions are the most significant, since they depend on the synchronic movement of appliance and radiographic film, it is possible to explain the origin of angular distortion of the third molars.

If a square is projected on a panoramic radiograph, and assuming that the angle formed between the middle point of this square and one of the internal angles is the long axis of the third molar, and that the vertical line of the square is the long axis of the second molar, there will always be a 45° angle. On a panoramic radiograph, the image of this square would always be distorted, especially in the horizontal direction, thus forming the image of a rectangle. If the same tracings are performed, from the middle point to the internal angles, taking the vertical lines as reference (herein considered as the long axes of the second molars), the angle formed between the central point of the rectangle and any of its internal angles would always be smaller than 45°, therefore explaining the results of the present investigation, as well as the tendency of the panoramic radiograph to exhibit a more mesial position of the third molars (Figure 7).

A clinically relevant aspect on the angulation of the third molars was highlighted in 1978, when the authors demonstrated that proper evaluation of this angulation is one of the factors that may predict the eruption or not of these teeth, thus contraindicating their removal.[10]

Therefore, during interpretation of the image of an unerupted third molar on a panoramic radiograph for surgical planning, one should consider that the teeth will be more distally positioned in the patient's mouth. This aspect is fundamental, so that the dentists may be prepared for occasional changes to their initial surgical planning observed during surgery.

The literature review retrieved one investigation that demonstrated the precision of the panoramic radiograph for evaluation of the position of third molars, and the authors observed a margin of error of 50% in the classification of teeth by dentists.[11]

With regard to the prevalence of position of the third molars in panoramic radiographs in the present study, the results were similar to those found in the literature, with a higher prevalence of third molars with mesial angulation, followed by the vertical position.[12,13]

However, analysis of the actual position of the teeth on the study casts revealed a higher prevalence of teeth with distal angulation, followed by the vertical position, in disagreement with the results reported in the literature on the prevalence of position of the third molars.[12–14] One explanation to these findings might lie in the classification of teeth on the panoramic radiographs as vertical, when in fact they clinically present distal angulation. This explains the more mesial position of the third molar on the panoramic radiograph revealed in the present study, in agreement with the literature, which demonstrated an increase in the angular values on panoramic radiographs.[15]

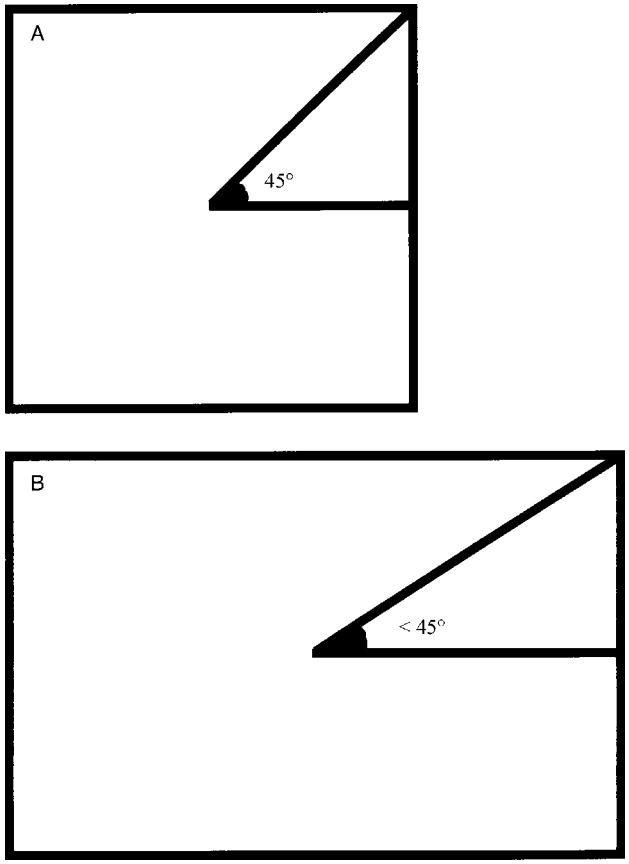

Figure 7 Relation between the central angles formed by a square (object) and a rectangle (image formed by the panoramic radiograph)

The dentist should further consider that mesial and distal angulations increase the risk of mandibular fracture after extraction of unerupted mandibular third molars.[16,17] The distal angulation further favours infection of the dental follicle, and thus should be taken into account during surgical planning and risk for post-operative alveolitis.[18,19]

The present results reinforce the findings of other authors on angular distortions, according to which the mean angular distortions of panoramic radiographs ranges from 5° to 6°.[15,20] This distortion should not be neglected for surgical planning of a mandibular third molar. Considering that the thickness of the bur for tooth sectioning employed at Bauru Dental School is 1.2 mm (4138 KG Sorensen®), and if these dental inclinations reflect alterations in the position of the third molar, with any displacement close to or larger than the thickness of the bur, this angular alteration might become clinically relevant.

Inclination of the third molar, in isolation, does not indicate the need for tooth sectioning. Divergent roots, thickness of the interradicular septum, root dilacerations and presence of hypercementosis should also be

considered. The angular distortion on the panoramic radiograph may also be responsible for planning of apparently simple tooth extractions because of vertical position of the tooth observed on the radiograph, which must be changed during surgery by accomplishment of ostectomies and tooth sectioning, not expected in the initial planning.

The radiographs achieved in the present study were obtained by a single experienced operator, in the same machine, which reduced possible alterations related to the radiographic technique.

It should also be considered that longitudinal investigations with radiographic follow-up of mandibular third molars usually reveal radiographic alterations in their position along time.[8,21] Because of these alterations in position of the teeth, the patients were submitted to surgery at most 1 month after achievement of the panoramic radiographs, in order to assure that position of the tooth would not be changed during this period.

These data reinforce the importance of recent radiographic examinations in the planning of extraction of third molars, so that the dentist may be concerned only with the distortions inherent to formation of the radiographic image. When there is a large time interval between achievement of the panoramic radiograph and surgery, besides the distortions, the dentist should also consider the tooth movement.

The angular distortions may vary in different machines, considering that the vertical and horizontal distortions also vary between machines.[4]

The present authors agree with statements in the literature that radiographic panoramic is a bidimensional image, and as such at least one other radiograph (occlusal or periapical radiograph) should be available for proper measurement of inclination and position of some object.[3–5] Nevertheless, we feel that the panoramic radiograph is a valid examination method for diagnosis and surgical planning of third molars, provided that the dentist is acquainted with its limitations and characteristics, even though others have stated that the panoramic radiograph is not a reliable resource for planning of extraction of unerupted third molars.[11]

References

1. Peterson LJ. Normas de conduta em dentes impactados. In: Peterson LJ, Ellis E III, Hupp JR, Tucker MR. *Cirurgia oral e maxilofacial contemporânea*, (3rd edn). Rio de Janeiro: Guanabara-Koogan, 2000: pp 96–102.
2. Pogrel MA. Complications in third molar surgery. In: Kaban LB, Pogrel MA, Perrpt DH, (editors). *Complications in oral and maxillofacial surgery*. Philadelphia, PA: W.B. Saunders Co., 1997: pp 59–66.
3. Alvares LC, Tavano O. *Curso de radiologia em odontologia*, (3rd edn). São Paulo: Ed. Santos, 1993.
4. Ávila MAG. Análise das distorções da imagem radiográfica em diferentes aparelhos panorâmicos. Bauru 1996, 124p. dissertação de Mestrado apresentada na Faculdade de Odontologia de Bauru.
5. Welander U, Tronje G, McDavid WD. Theory of rotational panoramic radiography. In: Langland OE, Langlais RP, McDavid WD, DelBalso AM. *Panoramic radiology* (2nd edn). Philadelphia, PA: Lea & Febiger; 1989: pp 38–75.
6. Winter GB. *Impacted third molars*. St. Louis, MO: Amer. Med. Book Co, 1926.
7. Pell GJ, Gregory GT. Report on a ten-year study of a tooth division technique for the removal of impacted teeth. *Am J Orthod* 1942; **28:** 660.
8. Hattab FN. Positional changes and eruption of impacted third molars in young adults: a radiographic 4-years follow-up study. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1997; **84:** 604–608.
9. Hattab FN, Alhaija ESJA. Radiographic evaluation of mandibular third molar eruption space. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1999; **88:** 285–291.
10. Haavikko K, Altonen M, Mattila K. Predicting angulational development and eruption of the lower third molar. *Angle Orthod* 1978; **48:** 39–48.
11. Chandler LP, Laskin DM. Accuracy of radiographs in classification of impacted third molar teeth. *J Oral Maxillofac Surg* 1988; **46:** 656–660.
12. Pinzan CRM, Sant'Ana E, Ferreira O Jr. Avaliação da freqüência da posição dos terceiros molares inferiores não irrompidos na Clínica de Cirurgia da Faculdade de Odontologia de Bauru – USP. Monografia Apresentada ao P.E.T. (CAPES), como requisito para conclusão do Programa. Bauru. 1999.
13. Deboni MCZ, Gregori C. Aferição das posições prevalentes dos terceiros molares inferiores inclusos. *Rev Odontol Univ São Paulo* 1990; **4:** 87–91.
14. Aitasalo K, Lehtinen R, Oksala E. An orthopantomographic study of prevalence of impacted teeth. *Int J Oral Surg* 1972; **1:** 117–120.
15. Amir C, Asja C, Melita VP, Adnan C, Vjekoslav J, Muritié I, et al. Evaluation of the precision of dimensional measurements of the mandible on panoramic radiographs. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1998; **86:** 242–248.
16. Lee JT, Dodson TB. The effect of mandibular third molar presence and position on the risk of an angle fracture. *J Oral Maxillofac Surg* 2000; **58:** 394–399.
17. Iizuka T, Tanner S, Berthold H. Mandibular fractures following third molar extraction. A retrospective clinical and radiological study. *Int J Oral Maxillofac Surg* 1997; **26:** 338–343.
18. Leone SA, Edenfeld MJ, Cohen ME. Correlation of acute pericoronitis and the position of the mandibular third molar. *Oral Surg Oral Med Oral Pathol* 1986; **62:** 245–250.
19. Osborn TP, Frederickson JR, Small IA, Torgerson TS. A prospective study of complications related to mandibular third molar surgery. *J Oral Maxillofac Surg* 1985; **43:** 767–769.
20. McDavid WD, Welander U, Kanerva H, Tronje G, Morris CR. Definitions of unsharpness and layer thickness in rotational panoramic radiography. *Oral Surg Oral Med Oral Pathol* 1984; **57:** 96–101.
21. Ventä I, Turtola L, Ylipaavalniemi P. Change in clinical status of third molars in adults during 12 years of observation. *J Oral Maxillofac Surg* 1999; **57:** 386–391.