Original Article

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ASTOL Technique: A Novel Method for Localisation of Impacted Mandibular Tooth

Dentistry Section

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ABSTRACT

Introduction: Object localisation is one of the challenges encountered in diagnosis of impacted teeth, which requires sophisticated two-dimensional and three-dimensional radiographic techniques. These sophisticated radiographs are not readily available in all clinics, and also they carry the risk of increased radiation exposure and increase burden of care.

Aim: To evaluate the accuracy of ASTOL (Arvind-Seerab Transmandibular Object Localisation) technique for object localisation in the dried mandible of a cadaver.

Materials and Methods: This cross-sectional study was conducted in Chennai city, Tamil Nadu between March 2021 to April 2021. A dried mandible of a cadaver and an extracted premolar was used to simulate 10 cases scenarios of impacted teeth at different regions of the mandible. Two Intraoral Periapical (IOPA) radiographs were taken for each scenario, from two different projections: first a conventional IOPA of the impacted tooth was taken and second radiograph was taken with the beam projected from the base of the mandible with the sensor placed on the occlusal surface. Both the radiographs taken for each scenario were incorporated into a questionnaire survey and were circulated to 30 dental practitioners. The results were tabulated and represented graphically. Cronbach's alpha test and Kappa statistics were done to evaluate the internal and interobserver reliability between the validators and respondents respectively.

Results: Out of the 30 dental practitioners, a total of 25 responses (14 males and 11 females) were received from dental practitioners across the state. The response rate was 83.33% and the mean age of the respondents were 34±5 years. The vertical position of the crown tip of the impacted tooth had a correct response rate of 85.60% (214/250). Angulation of the impacted tooth had a correct response rate of 75.20% (188/250). Mesiodistal positioning of the crown tip of the impacted tooth had a correct response rate of 78% (195/250). Buccolingual positioning of the impacted tooth had a correct response rate of 92.80% (232/250).

Conclusion: The ASTOL technique is a novel radiographic technique which can be used as an accurate, reliable and economic alternative to other sophisticated 2D and 3D imaging techniques for object localisation in the mandibular arch.

Keywords: Arvind-seerab transmandibular object localisation, Dental radiography, Diagnosis, Impacted teeth

INTRODUCTION

Localisation of objects and entities such as a tooth, pathology, or any foreign particle within the human body has always been an area of interest in the field of diagnosis. Visual examination is considered to be the gold standard for object localisation [1]. However, it is not always feasible and practically applicable to clinically visualise an object which is embedded within the hard and soft tissue. These anatomic limitations and the need for extensive diagnostic aids makes it a challenge in visualising these occult objects [2].

Dentistry in particular, involves the usage of radiographs for visualising structures which are clinically not seen such as the diagnosis of any impacted or supernumerary tooth [3]. Canines and premolars are two of the most commonly encountered teeth to be impacted within the maxilla and mandible, besides the third molars [4]. They pose several challenges to treatment planning and the outcomes as its location dictates the prognosis of disimpaction from an orthodontic perspective. Radiographs not just help with diagnosis, but also in localisation of the impacted teeth, assessing the severity and prognosis of the impacted teeth, which will help in treatment planning. Furthermore, it can also help in diagnosing any pathological transformation of the impacted tooth, if not addressed at the right time [5].

The commonly used modalities available for the purpose of localisation of oral structures are Cephalogram, Orthopantomogram (OPG) or Panoramic Radiograph, Computed Tomography (CT), and Cone Beam Computed Tomography (CBCT) [6]. However, the available plethora of modalities for imaging also come with their own limitations. Radiographic devices come with the risk of ionisation and require careful monitoring and dose limitation during usage. Their usage is weighed against the risk and benefit that comes with the process [7]. Extraoral radiographic devices are bulky, expensive, not easily accessible to all clinics, especially in rural areas [8,9]. Although CT and CBCT are highly accurate in visualising the occult structures, it is bound by its own limitations such as high radiation exposure, expense and difficulty of access [10].

Over the years, several methods have been employed to localise impacted teeth and other structures of interest. One such approach has been the tube shift method or parallax method or the Same Lingual Opposite Buccal (SLOB) technique as it is popularly known. It was described by Clark C.A. in the year 1909, where two radiographs were taken: one perpendicular to the tooth surface and one by shifting the X-ray tube mesial to the first projection [11]. This was further refined by Richard AG in 1952 as he introduced the Buccal Object Rule (BOR) [12]. These methods are, however, technique sensitive and require sound knowledge of the technique for its application. The other accepted modality of object localisation is a vertical tube shift method, which utilises a panoramic and an occlusal radiograph as it provides a wider field of vision for localisation of impacted tooth [13]. This method provides a better picture for localising an impacted tooth or other significant structures. However, the amount of radiation exposure is more in the vertical tube shift method as compared to the horizontal tube shift method, which employs IOPA radiograph [14].

This necessitates the need for an in-house technique for localisation of a tooth or an object within the confines of a dental clinic. A new approach called the ASTOL technique utilises intraoral radiographs/sensors to localise impacted teeth in the mandibular arch. Hence, the aim of this study was to evaluate the accuracy of the ASTOL technique to successfully localise hidden structures in the dried mandible of a cadaver.

MATERIALS AND METHODS

This was a cross-sectional study conducted between March 2021 to April 2021 on an online platform involving dental practitioners of Chennai, Tamil Nadu, India, to determine the efficacy of using occlusal IOPA for object localisation. Ethical clearance was obtained from the Institutional Review Board prior to the commencement of this study (IHEC/SDC/ORTHO-1905/22/350).

Inclusion criteria:

- A well-preserved mandible of a cadaver with all sets of complementary teeth present.
- Dental practitioners with a work experience of atleast one year.

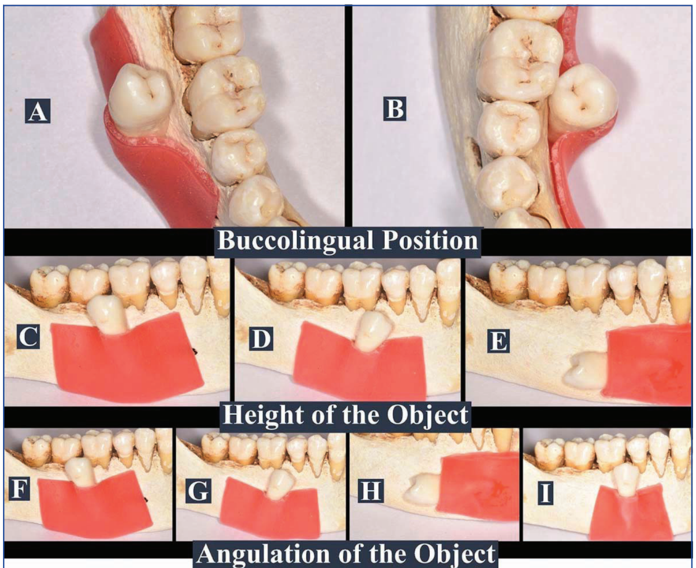
Exclusion criteria:

- Mandible of a cadaver with any pre-existing bony pathology.
- Mandible of a cadaver with any missing teeth.
- Dental students or practitioners with a work experience of less than one year.

Sample size calculation: Sample size calculation for the survey distribution was done using GPower software (Heinrich Heine University, Dusseldorf), version 3.0.10. Study conducted by Al Querban et al., was used for the purpose of sample size calculation [15]. The alpha level and power was set at 0.05 and 80% respectively for sample size calculation, which was estimated to be 30.

Study Procedure

A dried adult cadaver mandible used for this cross-sectional study, had all the teeth present, including the third molars and was free of any bony pathology. An extracted premolar was used as the object for localisation [Table/Fig-1]. The extracted premolar was placed at different sites varying the premolar's buccolingual position, angulations (mesioangular, distoangular, horizontal and vertical), heights (cervical third, middle third, apical third, below apex) and mesiodistal location in relation to the adjacent tooth [Table/Fig-1A-I]. A total of 15 case scenarios were simulated by positioning the extracted premolar in various regions of the cadaver mandible. The extracted premolar tooth to be localised, was secured in place to the cadaver mandible using modelling wax.



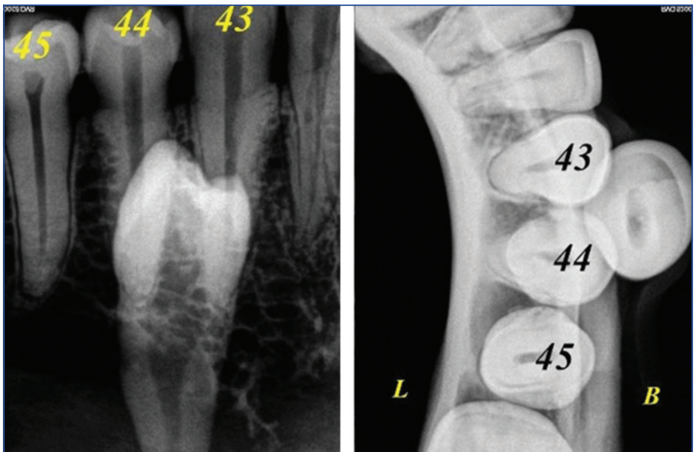
[Table/Fig-1]: Extracted premolar placed in different regions to simulate case scenarios; A-B) Showing the side where the extracted premolar is situated; A) Buccal; B) Lingual; C-E) Showing the height of the impacted tooth in relation to the root of the adjacent tooth; C) cervical third of the root; D) Middle third of the root; E) Apical third of the root; F-I) Showing the angulation of the impacted tooth; F) Distoangular; G) Mesioangular; H) Horizontal; I) Vertical.

The tooth secured in specific sites were photographed, to serve as the control. Two intraoral periapical radiographs for each scenario were taken using X-Mind DC X-Ray unit (Acteon, India). All the radiographs were taken with the standardised setting of 60 kV Tube voltage, 8 mA Tube current and Exposure time of 0.5s. Radiovisiographic (RVG) images were taken using RVG 5200 sensor (Carestream) [16]. The radiographs were taken using the paralleling angle technique. However, no extension cone paralleling holders (XCP holders) were used in this study.

Two radiographs were taken for each scenario. The first radiograph was taken by placing the RVG sensor facing the occlusal surface of the tooth covering the object to be localised, and the X-ray beam was projected from the base of the mandible, perpendicular to the sensor as shown in [Table/Fig-2]. The second radiograph was a standard IOPA image, taken by placing the RVG sensor parallel to the long axis of the tooth covering the object to be localised, on the lingual side and the X-ray beam projecting from the buccal side of the mandible, perpendicular to the sensor as shown in [Table/Fig-3].


[Table/Fig-2]: Radiovisiographic (RVG) sensor facing the occlusal surface of the tooth, and the X-ray beam projecting from the base of the mandible.
[Table/Fig-3]: Radiovisiographic (RVG) sensor perpendicular to the long axis of the tooth on the lingual side and the X-ray beam projecting from the opposite side of the mandible. (Images from left to right)

The RVG images were digitally processed and uniformly cropped for different orientations. The radiographic images were marked with directions and the teeth were numbered accordingly to aid in the orientation of the image [Table/Fig-4]. The tooth number identification was provided to overcome any confusions arising from the orientation of the image and to overcome the difficulty in determining the type of tooth in question, since these images do not have an embossed dot for mesiodistal orientation of the image and the participants have not visualised the specimen clinically.



[Table/Fig-4]: Radiographic image showing the two projections, with markings for direction and orientation (L-Lingual, B-Buccal).

Questionnaire Survey

A customised questionnaire was formulated using Google forms application. A set of 15 scenarios were initially framed, each of which had four sub-questions evaluating the vertical position of the crown of impacted tooth, angulation of impacted tooth, mesiodistal positioning of the crown of impacted tooth and the buccolingual positioning of the impacted tooth.

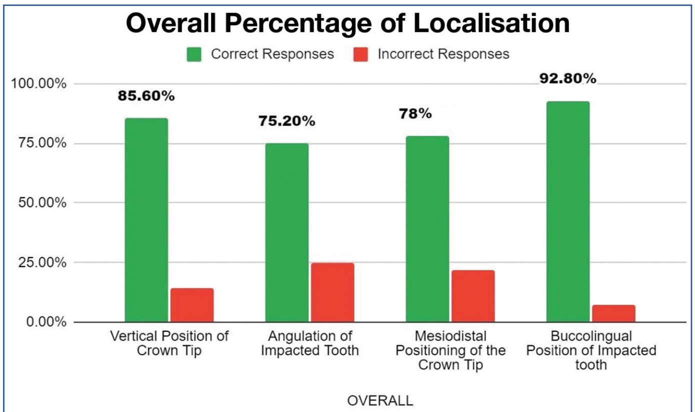
The questionnaire survey was first shared with 10 random dental practitioners to evaluate the validity, construction and feasibility of the questionnaire. Cronbach's alpha value of 0.875 was obtained, indicating good internal reliability of responses between the validators. Based on the initial responses of the validators and keeping in mind the length of the questionnaire survey, it was shortened to 10 case scenarios out of the 15 initially intended case scenarios due to the length and time taken for the questionnaire. The link for the revised questionnaire survey was then circulated among 30 random dental practitioners through electronic media such as Email, Facebook, WhatsApp, SMS and Telegram [Annexure-1]. The dental practitioners were chosen irrespective of their designation and field of speciality. Reminded messages were sent to all 30 practitioners at a span of one week to garner maximum responses.

STATISTICAL ANALYSIS

The results were obtained electronically, tabulated in a spreadsheet and were subjected to descriptive statistics using Microsoft excel 2019 MSO (Version 2202; Build 16.0.14931.20118). Cronbach's alpha test and Kappa statistics were done to evaluate the internal and interobserver reliability between the validators and respondents respectively [17].

RESULTS

Out of the 30 dental practitioners, a total of 25 responses (14 males and 11 females) were received from dental practitioners across the state, as a result of 5 drop outs, who did not responded to messages. The mean age of the respondents were 34±5 years, with an average work experience of 11±3 years. The overall percentage of object localisation in the four different aspects is shown in [Table/Fig-5].



[Table/Fig-5]: The overall percentage of correct responses for object localisation by the respondents.

The vertical position of the crown tip of the impacted tooth had a correct response rate of 85.60% (214/250). Angulation of the impacted tooth had a correct response rate of 75.20% (188/250). Mesiodistal positioning of the crown tip of the impacted tooth had a correct response rate of 78% (195/250). Buccolingual positioning of the impacted tooth had a correct response rate of 92.80% (232/250). The kappa value obtained was 0.83 which was a good agreement among the respondents.

DISCUSSION

The results of this study showed that a high percentage of subjects were able to accurately localise the position of the impacted tooth in all the four directions. High accuracy of localisation was seen with respect to the buccolingual positioning (92.80%) and vertical position of the impacted tooth (85.60%), whereas comparatively lesser yet good accuracy was seen in determining the mesiodistal positioning of the crown (78%) and angulation of the impacted tooth (75.20%). Both the mesiodistal and angulation assessment of impacted tooth requires orientation of the right and left sides of the image [18]. The relative decrease in accuracy of localisation seen in mesiodistal and angulation assessment might have been due to the use of RVG sensor for imaging, since these images do not have an embossed dot for mesiodistal orientation of the image [19].

Previous studies have compared reliability of various two dimensional (2D) radiographs like Orthopantomogram (OPG), Occlusal radiographs, Lateral cephalograms, Posteroanterior cephalograms (PA), Anteroposterior (AP) cephalograms and three dimensional (3D) radiographs like Computed Tomography (CT) and Cone Beam Computed Tomography (CBCT) for the purpose of localisation of impacted canines [9,13,20-24]. Previous studies have shown the use of panoramic radiographs to be a reliable modality of imaging for localisation of the impacted maxillary canines only. However, they have not documented its efficacy in localisation of impacted canines in the mandibular arch [25-27]. When the impacted tooth was near the apical third or above the roots of the adjacent tooth, it is difficult to palpate the impacted tooth clinically. In such situations the reliability of localisation of impacted tooth with OPG was found to be less [25,26]. Moreover, Lai CS et al., reported that panoramic radiographs were not reliable in localisation of impacted canines [28]. CBCT has been considered to be the gold standard for object localisation due to its ability to provide a 3D visualisation of the impacted object. Studies comparing the effectiveness of localisation of unerupted maxillary canines have shown that CBCTs were better than 2D radiographs [29,30]. However, it has higher radiation dosage than other conventional 2D radiographs [30-34]. Also, CBCTs are not readily available in most clinical setups and usually require external referral to Radiology centres. Moreover, they are much more expensive as compared to conventional 2D radiographs [35].

There are no prospective or retrospective studies till date, evaluating the effectiveness of periapical radiographs in object localisation or its comparison with other diagnostic modalities for object localisation. From our study we have found that IOPAs can be used reliably and accurately for object localisation in the mandibular arch. It also has the advantage of least radiation exposure as opposed to other diagnostic imaging techniques. This would make it a safe and simpler alternative to CBCT, which has 15 times higher radiation dose than a conventional 2D radiograph [36]. With respect to the radiation dosage, ease of availability and cost effectiveness, IOPA is a more feasible adjunct to any other radiographic modality in current practice. It also helps the diagnostician come to a faster provisional diagnosis, without the need for any additional imaging. Accommodation of an IOPA device in a remote clinical set up is more feasible than other larger 2D and 3D imaging devices [37]. By slight modification, this in-house technique can be used to localise a wide range of anomalies such as impacted teeth, any foreign object, sialoliths, cysts and odontomes in the mandibular arch or in the floor of the mouth.

Limitation(s)

One of the limitations of using this technique for object localisation would be that it cannot be used in the maxillary arch due to the superimposition of overlying structures as the X-ray source needs to be projected from over the head. Another limitation of this study would be the smaller sample size and the lack of embossed dot for orientation of the RVG image which could have resulted in reduction in accuracy of object localisation. The clinical impact of this limitation however, would be less as the operator will have a clear idea of the orientation of the RVG sensor while interpreting the image.

CONCLUSION(S)

More than 75% of subjects were able to accurately localise the position of the impacted tooth in all the four directions. The ASTOL technique is a novel radiographic technique which can be used as an accurate, reliable and economic in-house alternative to other sophisticated 2D and 3D imaging techniques for object localisation with respect to the angular, vertical, mesiodistal and buccolingual positioning within the mandibular arch. The reliability of this innovative method can be further tested in an in-vivo set up, which would be the scope of our future research.

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