



## Using Mind maps to understand the role of orthodontists in Forensic Odontology: An illustrative review

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### Abstract:

Orthodontics, a branch of dentistry, is known for meticulous comprehensive standardized patient records. Besides, the expertise of orthodontists in assessing radiographs for age assessment, skull, and dental profiling along with facial morphometric parameters puts them at an advantage for forensic on-field application. The advent of technology with the inclusion of software, digitization of models, and machine learning algorithms have strengthened their disposition in forensic dentistry further. Hence, to comprehend and summarize the role of orthodontist in forensic dentistry, this article uses novel mind mapping pedagogical approach to give a visual structural organised demonstration to the readers for better understanding. In a series of 9 mind maps, each aspect which of key roles have been explored and presented.

**Keywords:** Forensic dentistry, Mind map, Orthodontics, forensic facial approximation, age estimation, medical illustrations.

### Introduction:

Forensic odontology (FO) is an interdisciplinary division of dentistry where each discipline provides expertise to deal with the appropriate storage, handling and investigation of dental evidence, to be produced in the court of law. Orthodontics, amongst all branches of dentistry, is well known for comprehensive standardized patient data collection with proper labeling and storage for many years in succession. Orthodontics has found its use in all the three major FO applications:

**a) Civil field:** Concerned with mass disasters including earthquakes, airline or train accidents which require ante-mortem records of the deceased or injured for identification. Malpractice or age frauds, which may require age assessments based on teeth or radiographs.

**b) Criminal field:** Identification of deceased or accused in the cases of rapes, homicides, etc. by bitemark analysis or adjuncts like rugae and lip print analysis.

**c) Research field:** Many research avenues related to age estimation or reconstructive profiling are initiated in dental/orthodontic under-graduate (UG) and post-graduate (PG) levels.

To exemplify the detail of the role of orthodontists in the above three domains, it is important to gather all the scattered information and present it systematically for better comprehension. Various authors have suggested usage of concept maps / mind maps may be one of the teaching and learning strategies in medical perspective, which can foster critical thinking for structured visualisation of information. This innovative pedagogical strategy is not new and has been used in understanding various medical and paramedical domains, which include medical education, dental education, nursing education, pediatric and geriatric patients, and also orthodontic patients.

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Although, literature evidence suggests a well-established contribution of orthodontists in the field of forensic odontology, but for conceptual understanding about the importance of orthodontists in the forensic team can be well demonstrated with the help of mind maps.

Hence, the aim of current article is to explore the key roles of an orthodontist in forensic dentistry with the help of mind maps, presenting information in a visually well-organized, structural form based on sound literature evidence and personal expertise.

**Methods:**

Mind maps, in the current article, have primarily three main components:

**a) Central theme:** In this case: “Role of Orthodontist in Forensic Dentistry”

**Mind Map 1 (Figure 1):** Represents the key areas where the orthodontist plays a role during forensic investigations, based on the collection of records and their practical, theoretical, and clinical expertise.

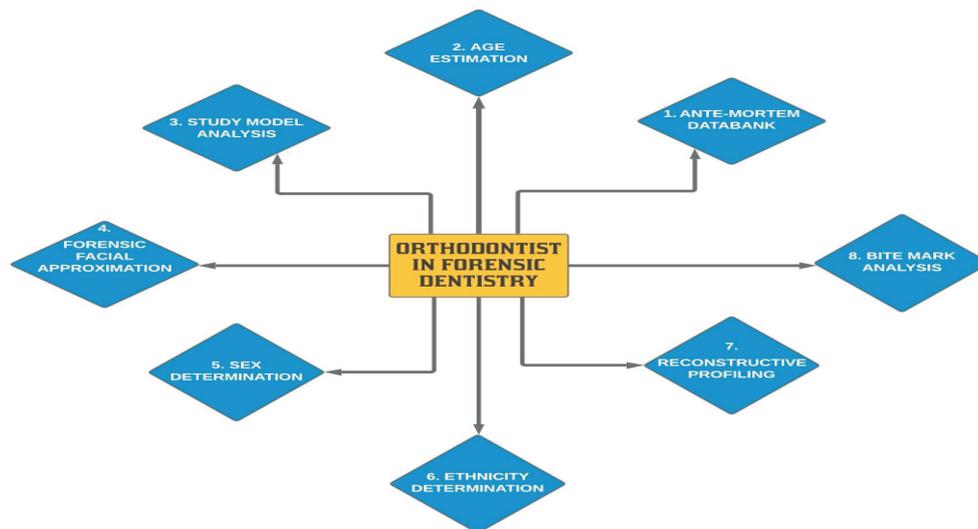


Figure 1: Mind-Map 1 represents eight key areas of role of orthodontist in forensic applications.

**Eight areas have been identified:**

1. Ante-Mortem Records
2. Age Estimation
3. Study Model Analysis
4. Forensic Facial Approximation
5. Sex determination
6. Ethnicity determination
7. Reconstructive profiling
8. Bite Mark Analysis

**b) Branching theme:** In this case, all eight major sub-heads which are descriptive of the role of the orthodontists are explained in the branching themes (branches) which are further sub-branched (twigs) for giving explanations in subsequent mind-maps.

**c) Visual representation:** In this case, the central theme is represented by a similar diagram, font, and color characterization in all the mind maps to give a visual sequence to the readers. The branching concepts are also provided with the same color scheme for the ease of being self-explanatory. The arrows explain the inter-branching of ideas and concepts.

**Results:**

The concepts are presented in the form of nine mind maps (Figure 1-9) for better explanation.

**Color coding represented in the current mind maps:**

The following color coding has been applied in the mind maps as represented in the article:

- a) Yellow with black large text font: Central theme “Role of the orthodontist”
- b) Dark blue with white bold text font: “Branching themes”: identified eight areas of orthodontic expertise
- c) Pink with black regular text font: Sub-heads representing major subheads, which give way to twigs (Green and Blue colors) of related concepts or ideas which are varied in different mind maps.

1. Ante Mortem Records

(Mind Map 2, Figure 2): Primarily used for comparison with post-mortem data of the deceased or with the records of the accused of criminal or civil offense in question. These include:

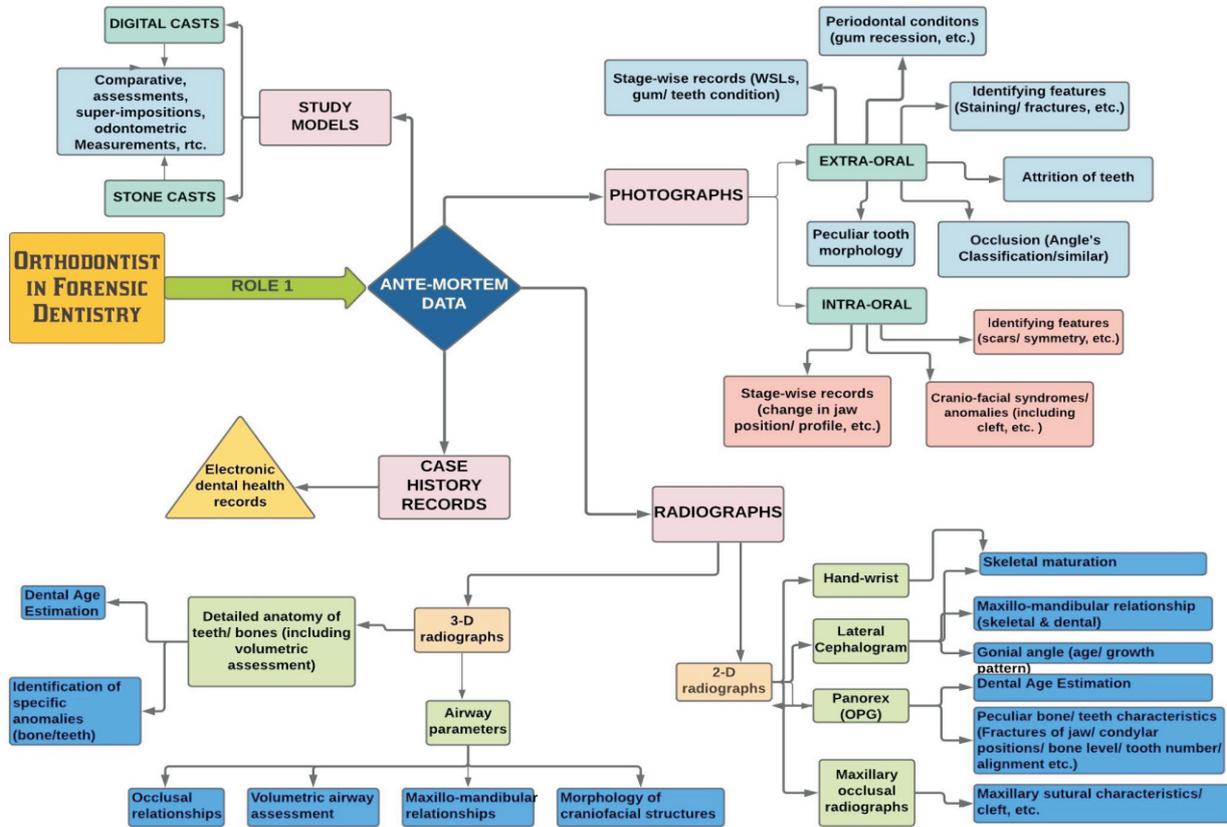


Figure 2: Mind Map 2 represents details of ante- mortem data bank which can be provided by the orthodontic records.

a) **Photographs:** Orthodontist takes a set of standard intra-oral (frontal, right, and left lateral, maxillary and mandibular occlusal) and extra-oral (frontal, 45 degrees, profile,) for each patient. It is stored for each treatment stage and can be useful in assessment as the antemortem record or for comparative profiling. Besides any more information that can be derived from these photographs is explained in Figure 2. The role of quality photography in forensic dentistry has been highlighted by Bernstein ML, 1983 and orthodontists can play a pivotal role.

b) **Radiographs:** Minimum set of radiographs including orthopantomograms (OPGs)/ panorex, and lateral cephalograms are usually advised for all fixed orthodontic or functional appliance treatment. But peculiar conditions might require additional radiographs, of which 3-D (3-

Dimensional) CBCT (cone beam computed tomography) taken specifically in impactions or airway assessment can be directly used for comparative identification. Measurements in these radiographs can further aid age estimation and anatomical assessments of maxilla and mandible along with temporomandibular joints. The importance of standard radiographs for identification and ante-mortem or post mortem comparison has been highlighted by Manigandan T *et al*, 2015.

c) **Case history:** Case history records, preferably dental electronic health records (EHRs) can provide an excellent insight into the detailed history of the individual dental, medical, and family history. A recent article by Nuzzolese E (2020) has proposed using blockchain technology for EHRs using a forensic interface for identification of human remains and retrieval of comparative data.

**2. Age determination[Mind Map 3, Figure 3]:**

The dental age estimation is primarily done on OPGs by atlas method of comparison (Schour and Massler, London Atlas, etc.) or scoring method (Demirjian, DAEcc chart, etc.) or shape assessments (eg. Camariere methods), as compiled by Kapoor P *et al*, 2018. The orthodontists routinely perform these assessments, besides estimating skeletal age by cervical vertebrae maturation. Newer machine learning algorithms are also being applied routinely for age assessments, researched and published both in recent forensic and orthodontic journals.

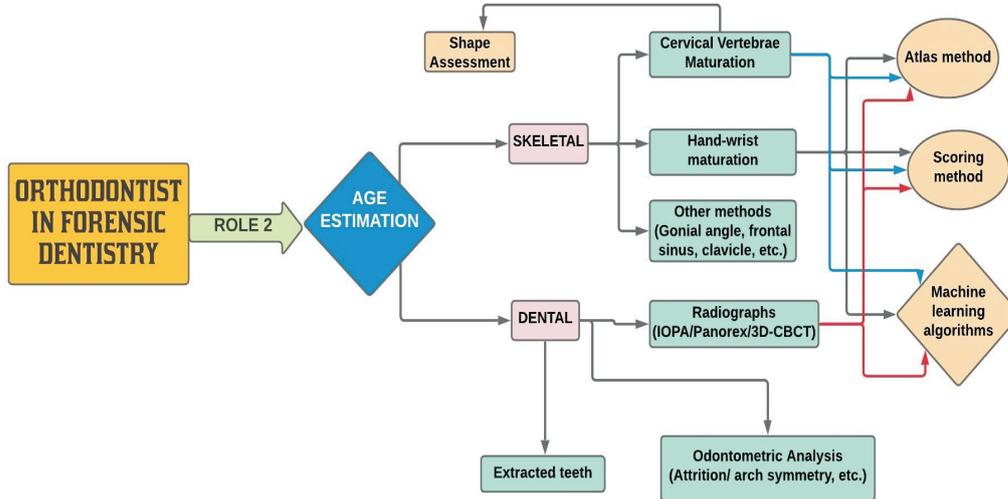


Figure 3: Mind Map 3 represents orthodontic expertise in dental and skeletal age estimation, which can be used for forensic purposes.

**3. Study Model Analysis (Mind Map 4, Figure 4):**

3-D replica of teeth can provide an immense amount of information for identification and reconstructive profiling. The advent of digitized 3-D models can solve the problem of storage and transfer and can be conveniently used for analysis and superimpositions. Besides, rugae pattern has proven stability in forensic identification, assessed on study models, even when subjected to maxillary palatal expansion.

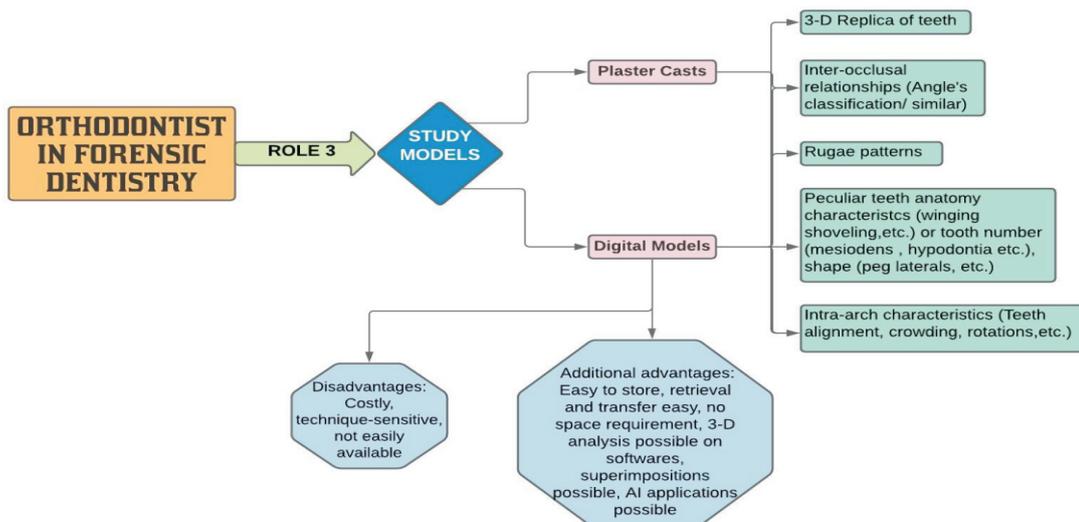


Figure 4: Mind Map 4 represents role of orthodontist in forensic facial approximation (FFA), both in clinical and research data aspects.

**4. Forensic Facial Approximation (FFA) (Mind Map 5, Figure 5):**

The three main components of FFA- anatomical modeling, morphologic determination, and final reconstruction can be aided by the orthodontists with their expertise. In addition to the knowledge, practice experience of orthodontists taught in the PG curriculum, the manual dexterity skills, as well as manipulation of dental materials also come handy while performing FFA. Besides, orthodontists can assess growth-wise changes in 10 medial and 11 lateral points while investigating facial soft tissue thicknesses (FSTT), which can be collected as research data and serve as inputs for automated facial reconstruction programs for different ethnicities.

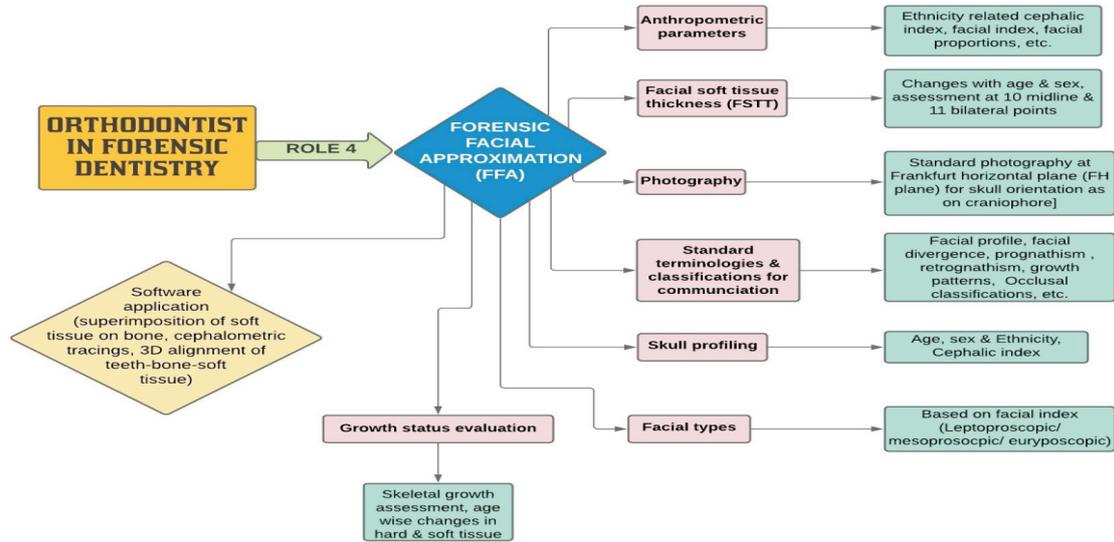


Figure 5: Mind Map 5 represents the teeth, skull, craniofacial skeleton and soft tissue analysis for sex determination.

**5. Sex determination (Mind Map 6, Figure 6):**

Sex-based differences amongst males and females based on dental morphometric traits, or eruption and development pattern, can be assessed by orthodontists through odontometry of dentition, and study of clinical casts and radiographs skull measurements as well as morphological assessments. Additionally, FSTT variation with age in both the sexes has been well taught in the orthodontic curriculum, which can be applied to the practice of FFA.

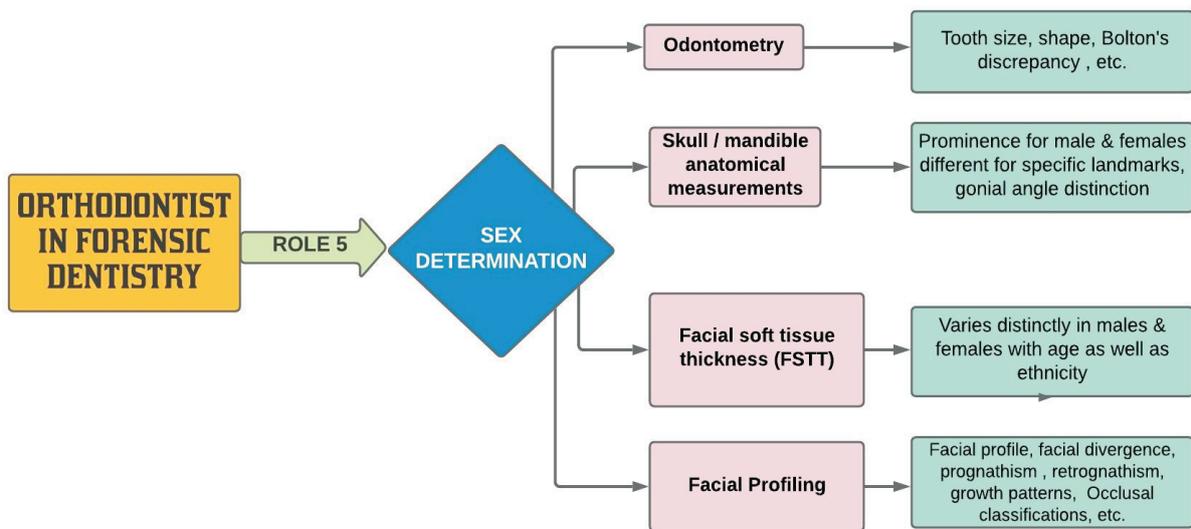


Figure 6: Mind Map 6 represents the teeth, skull, craniofacial skeleton and soft tissue analysis for ethnicity determination.

**6. Ethnicity determination (Mind Map 7, Figure 7):**

Dental metric and non-metric dental traits including Arizona State University Dental Anthropology System (ASUDAS) give an indication of the ethnicity of an individual, well documented by Chowdhry A, 2018. These morphologic traits are well documented in the orthodontic case history sheet, more so as they may pose difficulty in orthodontic treatment and retention, but they prove useful for forensic profiling of an individual. Besides metric and non-metric skull-based parameters also show differences in both the sexes. Also, habits and craniofacial measurements may speak volumes about the ethnicity of the individual

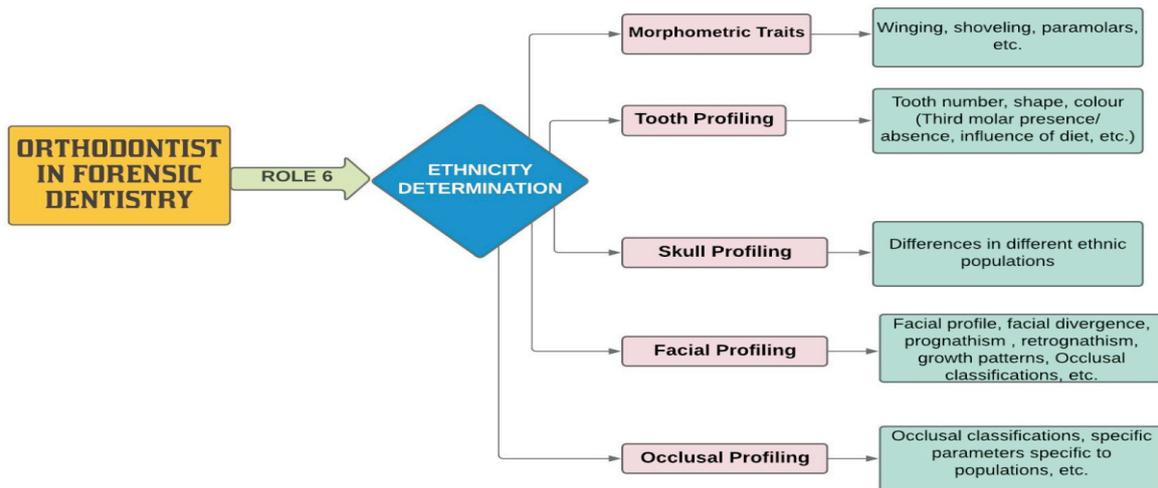


Figure 7: Mind Map 7 represents role of orthodontists in all major aspects of profiling including age, sex, ethnicity determination along with habits.

**7. Reconstructive Profiling (Mind Map 8, Figure 8):**

Age, Sex, and ethnicity determination, as explained in previous sections contribute towards reconstructive profiling of an individual. Besides, certain traits like incisal fractures, etc. also give indication about occupation hazards or upper proclination may indicate mouth breathing or thumb sucking habits.

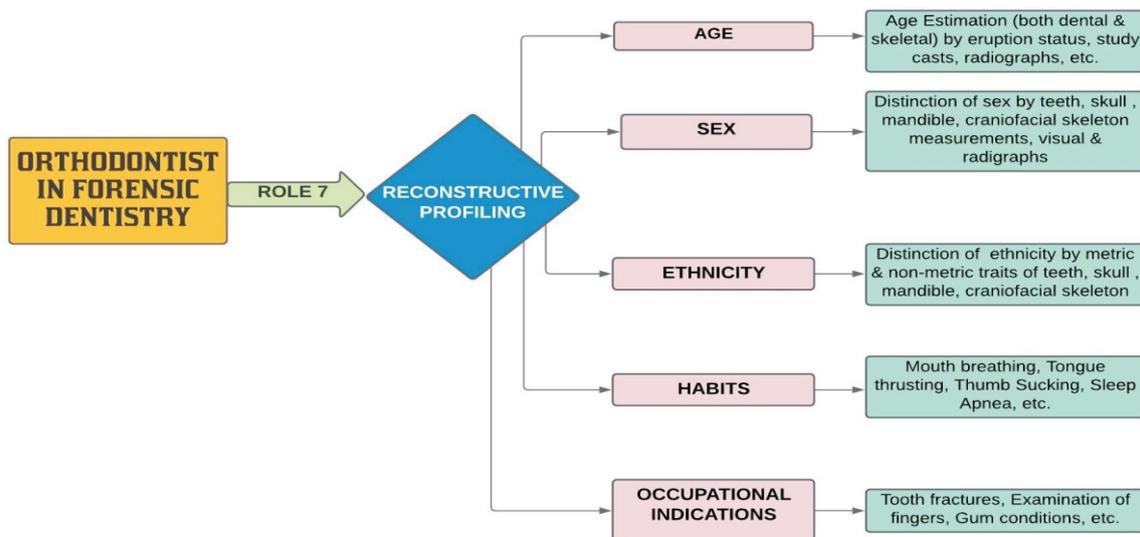
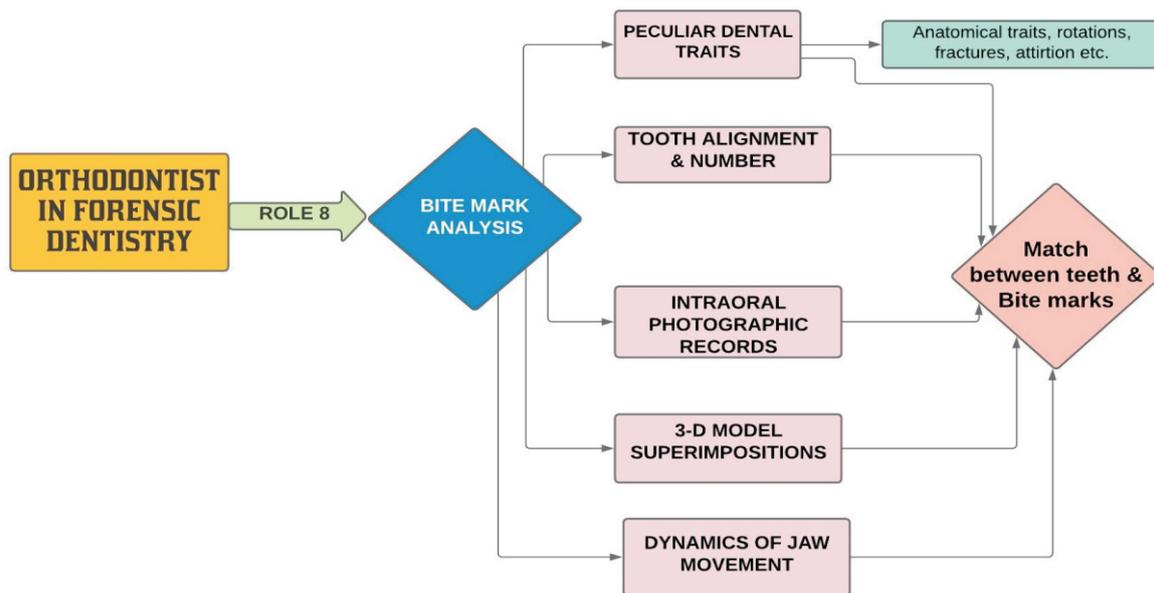


Figure 8: Mind Map 8 represents role of orthodontists in bite mark analysis by identification of peculiar characteristics as well as overlays.

**8. Bite mark analysis (Mind Map 9, Figure 9):**

The peculiarities in dentition (rotations/ fractures/ crowding, etc.) can contribute to the grading of positive identification of a suspect when compared to the bitemark, based on the class and individualistic characteristics, as per ABFO guidelines. Studies have focused on analyzing bite mark patterns on different materials like skin and clay, and found that unique dental patterns can lead to proper harvesting and investigation of bite marks. The stored photographs and study casts of suspects from orthodontic records can come handy, as overlay for bite marks using Adobe Photoshop or GIMP etc software.



**Conclusion:**

Multiple mind maps have been utilized in our current article to simplify and understand the multifaceted role of an orthodontist in forensic investigations. Their role includes offering a source of ante-mortem records to extending their theoretical know-how and practical expertise in applying skull and facial indices and proportions for skull and facial profiling for reconstructive/ comparative identification.

Mind maps highlighted that the changes in skeletal and dental characteristics with age or influenced by differences in sex and ethnicity can be a source of the generation of huge raw data to be implemented by FFA specialists while reconstruction. This article not only presents, the different aspects of orthodontic roles but supports it in the light of current evidence of automation, artificial intelligence, and machine learning algorithms. It extends a strong proposal to the forensic specialists to work in tandem with orthodontic specialists for a comprehensive approach towards forensic applications.

We suggest usage of mind maps in other sub domains of forensic odontology for enhanced understanding and translation research application of the subject. This will lead to overall growth of the subject itself.

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