

Microscopy in Forensic Odontology: Scope and Applications

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Abstract

A milestone in the world of science, microscope has revolutionized the field of modern forensics. Over the years the field of microscopy has come a long way and has paved ways for newer techniques of evaluation of evidences from various scenarios like natural disasters, criminal cases, suicidal cases etc. which if done conventionally might be missed by naked eyes of the investigator. It plays an inevitable role in examination of soil, dust, fibres, hair or other trace material by forensic scientist, study of genome by forensic epidemiologist, analysis of DNA by a geneticists and evaluation of soil, water, any building component, bullets found at the crime scene. Here too, the microscopes are of great help in several domains like in comparison of dental structures, in age estimation that applies the histologic methods, examination of various evidences collected from the crime scene, etc. Conventional microscopic techniques involve transmitted-light, absorption microscopy which is appropriate for coloured objects of resolvable size, and instrumentally is the simplest form of microscopy. Colourless, transparent objects can be studied only by retardation techniques (polarization, phase-contrast, interference; these techniques depend upon conversion of phase retardation which leads to changes in intensity of light that can be seen by the eye. Hence these evolving techniques in microscopy add value and precision in evidence collection and evaluation. The present review article is prepared with an aim to compile and highlight the applications of several range of microscopes under forensic odontology perspective. This review article may be a used as a ready reference to apply the microscopic techniques in investigations dealing with dental exhibits.

Keywords: Microscopes; Forensic Odontology; Stereomicroscope; Scanning Electron Microscope; Phase Contrast Microscope; Comparison Microscope

Introduction

Forensic Science is a multidisciplinary, multi-dimensional specialty which deals with the application of almost all branches of science under legal context. The teeth being the hardest and the strongest substance in human body, have the potential to resist environmental, thermal and taphonomic changes and can therefore be considered as one of the most reliable and well-grounded form of evidences, especially in forensic human identification cases [1]. The developing dentition provides a valuable information related to the age of individual right from the intrauterine life till adolescent. As the maxilla, mandible grows along with development of tooth, various modifications occur over the years at different stages of growth & development which can be monitored and

employed as a guide for identification of age, sex, ethnicity, cause of death & identification of victim and suspect etc. in the civil and criminal judicial system. So, the evidences from oral and maxillofacial region can play a vital role in human identification in case of mass disasters, domestic violence and child abuse cases. Microscopes are compound to complex instruments consisting of optical lenses, illumination, mirrors and other supporting system that helps in magnifying the tissue or object, revealing the fine details which cannot be perceived by naked human eye. The purpose of using microscope is to obtain detailed information about the morphology, size, texture, structure, chemical constituent and electrical properties of the samples or objects [2-4]. Understanding of these minute details seen under the microscope can widen the scope of identification of human remains.

Table 1: In this article we will illuminate the use of different microscopes like

TRAIT/ FEATURE	METHOD	MICROSCOPE USED
Age Estimation	<p>Cemental Annulations: Longitudinal section of teeth shows dark band (Incremental lines of Salter) expressing the end phase of mineralization with alternate white band. This expression of altered dark and light band is due to change in orientation of bundles of collagen fibers. Combination of an alternate light and dark band is considered as one annulation which when counted microscopically can aid in age estimation.</p> <p>^[5] Secondary Dentin Thickness: Secondary dentin deposition occurs regularly throughout the life, without being affected by external conditions like the periodontal status of tooth leading to reduction in the size and volume of pulp chamber. It can be measured qualitatively by Gustafson's method (more reliable) and quantitatively by Kedici's method.</p> <p>^[6] Surface Alteration: Attrition, Abrasion, change in color, Root-Dentin translucency. Change in color depends on thickness, texture and orientation of crystals, which varies with age and undergo alterations with increasing age.</p> <p>^[7] Transparent Dentin: Nanotechnology of TEM can be used to detect changes in mineral phase of transparent dentin and can help in estimation of age.</p> <p>^[8]</p>	<p>Light Microscope, Phase contrast microscope(Figure-2) Polarizing microscopeStereomicroscopeStereomicroscopeTransmission Electron Microscope</p>

.Sex Determination	<p>Bar Body in dental pulp: Females have XX chromosomes. In order to prevent transmission of unnecessary information to next generations, one of two X chromosome is inactivated in somatic cells via Ionization. Histologically it can be seen as darkly stained basophilic round to oval body exclusively seen in females. It can be detected in pulp cells.^[9]</p> <p>F body: The Y chromosome is unique in that it is only found in male. A fluorescent dye, quinacrine, binds strongly to the Y chromosome and a bright fluorescent spot (F body) is clearly seen under ultraviolet light.^[10]</p>	Fluorescent Microscope(Figure-3)Fluorescent MicroscopeStereomicroscope
Cheiloscopy –Gender & Ethnicity Determination	<p>Study of pattern formed by creases and grooves on the surface of lip is called as cheiloscopy. Being unique to every individual, it can serve as an effective tool in determination of personal identity, race & gender. Commonly found in sexual assault cases, murders, child abuse, domestic violence cases etc. Most common classification used is given by Suzuki and Tsuchihashi depicting 5 different patterns. Various studies have shown that men are likely to have different patterns in all 4 quadrants while females tend to have similar patterns in all the quadrants.</p>	Stereomicroscope(Figure-4)
Dental Anthropology	<p>Special morphological characteristics of tooth : presence of cusp of carabelli, hypocone, protostylid, shovelling of incisors, variation in size and shape, pathologies, wear patterns helps in identifying the ethnicity of an individual.^[11] As some characteristics are predominant in some racial groups.</p>	Light MicroscopePhase contrast microscope Polarizing microscopeStereomicroscope(Figure-5, 6)

Pink Tooth Phenomenon(Forensic Thanatology)	It denotes cadaveric decomposition and microscopically can be detected in H & E stained decalcified sections by presence of haemoglobin in dentinal tubules, saturated with carbon Dioxide. ^[12]	Compound Microscope
Rugoscopy	Palatal rugae once formed, only increases in length. Due to its hard structure, it can withstand severe trauma & burns as it is shielded by lips and cheeks. Therefore, it can be used in mass disasters like plane crash accidents, floods, fire accidents etc. for determining personal identity, gender and ethnicity of an individual/ cadaver. It can be used in forensic cases in which finger print and lip print cannot be utilized due to decomposition and incineration. ^[13]	Stereomicroscope
Bite Mark Analysis	A bite-mark refers to an indentation on skin or any substance caused by a bite which in itself is a dynamic process determined by shape and size of dental arch and teeth, motion of muscles, pressure and intention of biter. Presence of any developmental anomaly of teeth, carious lesion or any restoration can be used effectively by analysing the cast and can therefore be compared to solve the case. ^[14]	Stereomicroscope Comparison microscope(Figure-7)

Amelogyphics	Enamel rods end on the tooth surface at different levels and in different directions, resulting in specific patterns on the tooth surface. The study of these enamel rod end patterns is known as amelogyphics. Their study under electron microscope determines the uniqueness of this pattern in relation to gender as well as type of dentition i.e. primary and permanent. ^[15] Eg: In case of fire accidents tooth can serve as a promising evidence as it can withstand high temperature.	Scanning Electron Microscope(Figure-8)
Tongue Print	Tongue is dynamic organ with unique features which can be of utmost importance for identification on the basis of size, shape, texture, type and pattern of grooves on the dorsal surface of tongue has proved to be beneficial in gender identification. Various studies have shown females tend to have a sharp tip at the apex, while men have septate tip. ^[16] Histologically, differences in orientation of muscle fibres especially in the middle region of tongue has shown sexual dimorphism.	Stereomicroscope,Light Microscope
Microbial Analysis Of Biofilms- Bio imaging	TEM is used in identification of morphological characteristics of bacteriophage. Dark field and Phase contrast microscopes provide high resolution images of biological samples. ^[17]	Transmission Electron Microscope

Neonatal Line	<p>It is a hypo-mineralized structure present on the surface of enamel of all primary and permanent first molars & marks live birth. In the field of forensic odontology, it can be used as an evidence of live birth against still birth in cases of neonaticide. In presence of neonatal line, the amount of hard tissue formed can be used as an evidence to estimate the chronological age.^[18]</p>	Compound Microscope Polarized Microscope Scanning electron Microscope
Diatoms	<p>In case of drowning, directing the case study by determining the location and characteristics of diatoms which are single celled algae with transparent membrane containing opaline silica. Also helps in reviewing biomineral formation in diatoms. In criminal cases it helps in determining the time of deposition of bloodstains therefore estimating the time of occurrence of crime^[19]</p>	Atomic Force Microscope(Figure-9)
Forensic Entomology	<p>It is a branch of forensics that helps in estimating the Post Mortem Interval (PMI) by identifying the larva and eggs of insects and other arthropods found on the corpse during the early and late stages of decomposition. Microscope like SEM can help in visualising the morphological changes occurring throughout the life cycle of insect and therefore adequate knowledge of the cycle can help in determining the PMI.^[20]</p>	Scanning Electron Microscope Comparison Microscope
Forensic Anthropology	<p>Mandible being a strong bone can withstand harsh conditions and trauma. In anthropological studies mandible along with coated teeth have been studied for indicating possible cause of death.^[11]</p>	Scanning Electron Microscope

Food Composition Analysis	To identify and characterize food elements which can be found in the form of dried vomit deposits on the clothes, any food deposits from the soil or site of interest. Food products showing birefringences collected from the site can also be visualized under polarized microscope. ^[21]	Polarizing Microscope Stereomicroscope
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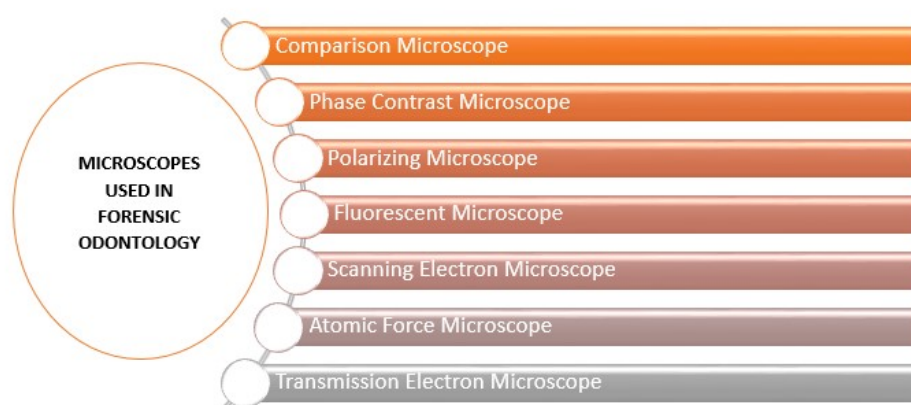


Figure 1: Various Microscopes used in Forensic Odontology

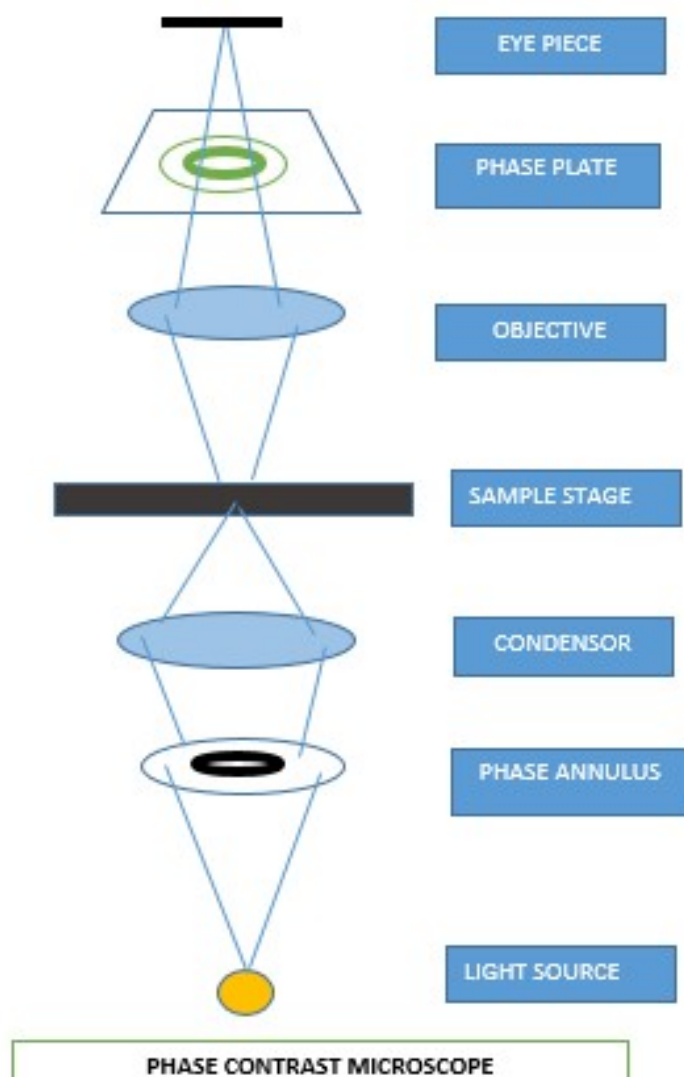


Figure 2: Phase Contrast Microscope- Schematic Diagram

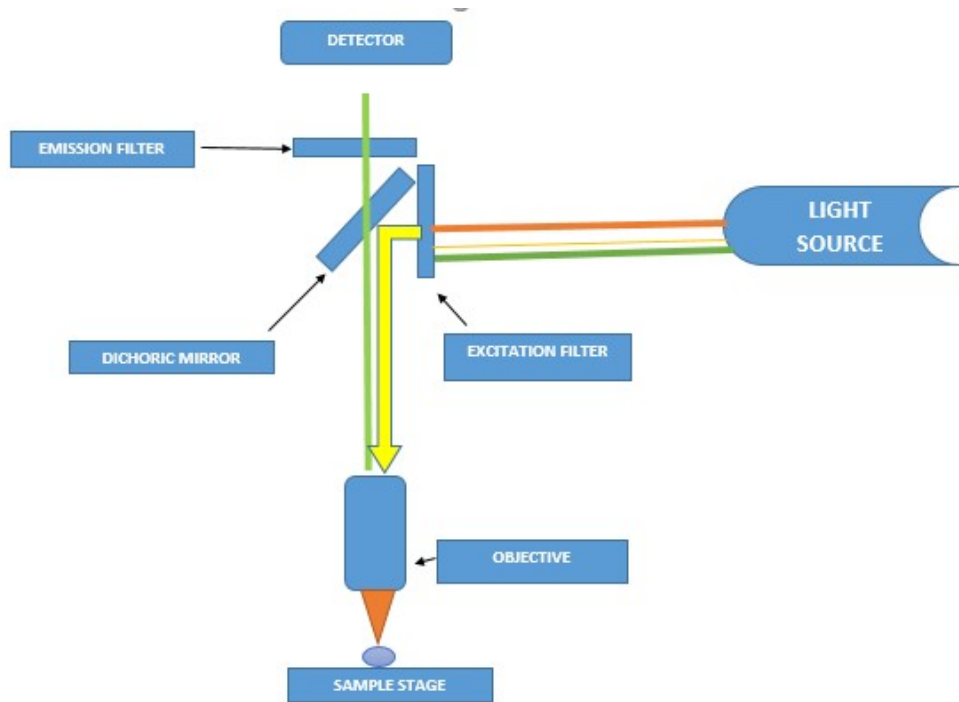


Figure 3: Fluorescent Microscope- Schematic Diagram

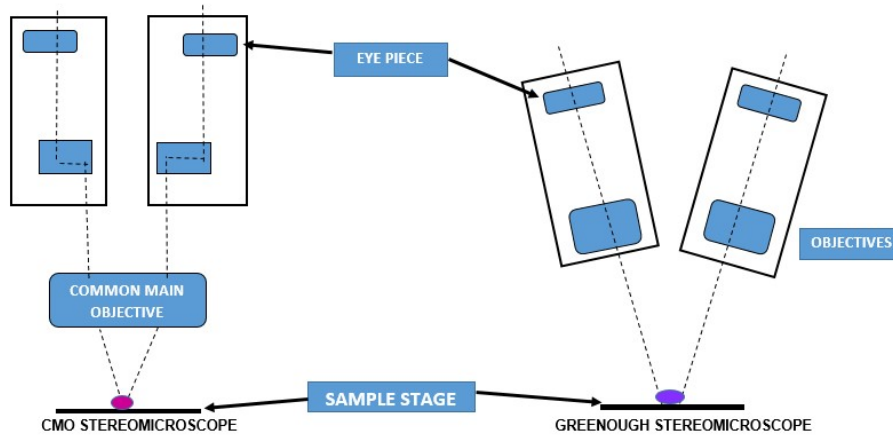


Figure 4: Stereomicroscopes- Types and Schematic Diagram

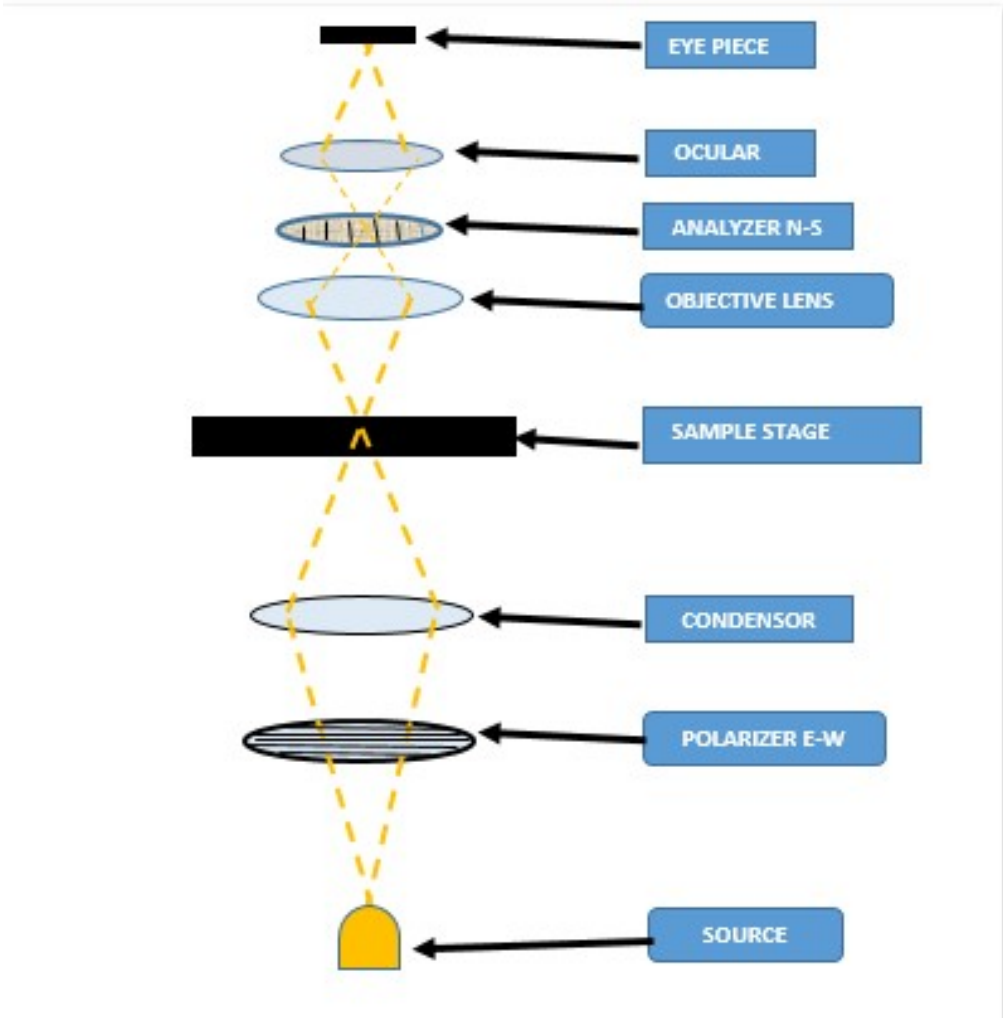


Figure 5: Polarizing Microscope- Schematic Diagram



Figure 6: Stereomicroscopic image of Molar tooth showing attrition facets on occlusal surface. (Courtesy- Dr. Harita Paghadal, PG student, GDCHA)



Figure 7: Comparison Microscope

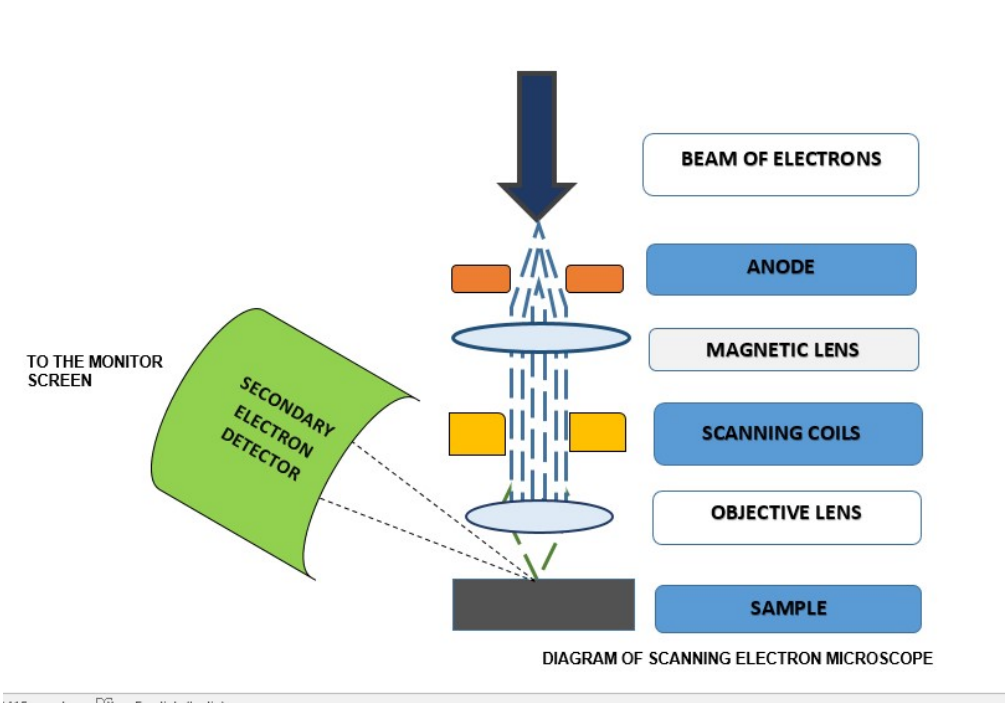


Figure 8: Scanning Electron Microscope- Schematic Diagram

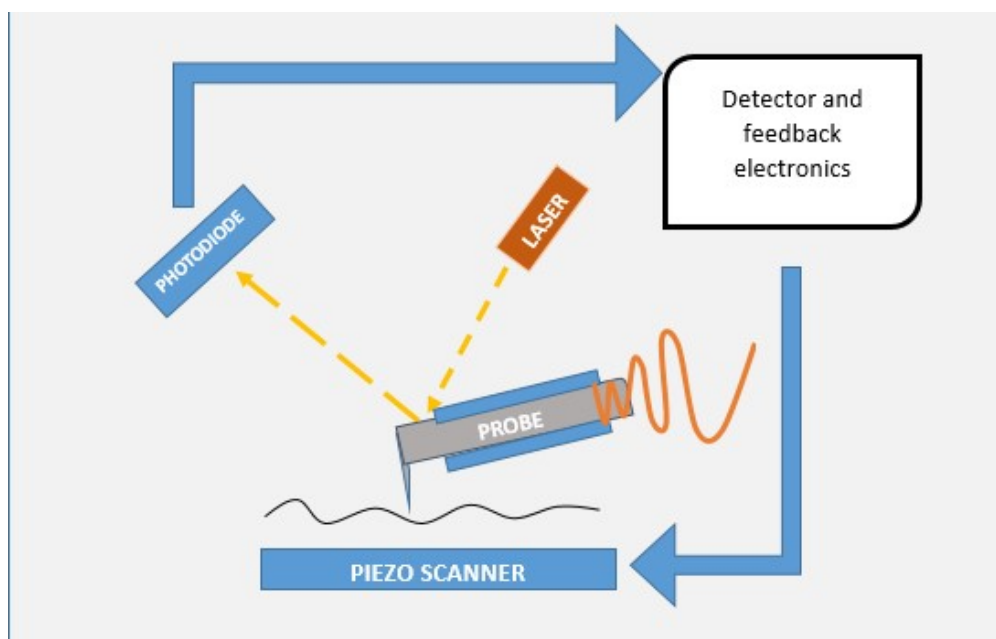


Figure 9: Atomic Force Microscope- Schematic Diagram

Conclusion

This article serves as a ready reckoner for illuminating the utility of different types of microscopes in the field of Forensic Odontology. This article summarizes the mechanism of action of compound and other advanced microscopes, along with their abilities to evaluate and analyze characteristic features from oral and maxillofacial evidences in estimating the age, sex, race, comparing ante-mortem and post-mortem evidences and determining the type of accident or crime.

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