"EVALUATION OF METRIC & NON-METRIC DENTAL FEATURES IN ETHNIC GROUPS OF ASSAMESE POPULATION FOR FORENSIC PROFILING: A CROSS-SECTIONAL STUDY"

By

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Dissertation

Submitted to

KAHER, Belagavi, Karnataka

In partial fulfilment of the requirements for the degree of

MASTER OF DENTAL SURGERY

IN

ORAL & MAXILLOFACIAL PATHOLOGY & ORAL MICROBIOLOGY

(BRANCH - IV)

DEPARTMENT OF ORAL & MAXILLOFACIAL PATHOLOGY & ORAL MICROBIOLOGY

KAHER'S KLE VISHWANATH KATTI INSTITUTE OF DENTAL SCIENCES, KAHER,

NEHRU NAGAR, BELAGAVI-10, KARNATAKA

2022-2025

KLE ACADEMY OF HIGHER EDUCATION AND RESEARCH, BELAGAVI, KARNATAKA

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ABBREVATION

SL.NO	ABBREVATION	FULL FORM
1	%	Percentage
2	i.e.	That is
3	No.	Number
4	NMt, nm	Non metric
5	MD	Mesiodistal
6	BL	Buccolingual
7	UI	Upper incisor
8	UL	Upper lateral incisor
9	UC	Upper canine
10	UPM	Upper Premolar
11	UM	Upper molar
12	LI	Lower incisor
13	LL	Lower lateral incisor
14	LC	Lower canine
15	LPM	Lower Premolar
16	LM	Lower molar
17	NER	North Eastern Region
18	NE	North East
19	FO	Forensic Odontology
20	DVI	Disaster Victim Identification
21	LRA	Logistic Regression Ananlysis
22	ML	Mesiolingual

23	DL	Distolingual
24	FO	Forensic odontology
25	Mt	Metric Traits
26	OC	Occluso-cervical
27	Yrs	Years

ABSTRACT

Background: Human identification is based on scientific principles, mainly involving dental records, fingerprints, estimation of age, postmortem reports, differentiation by blood groups, and DNA comparisons. Sex assessment is one of the prime factors employed to assist with the identification of an individual with morphometric dimension of teeth.[74] Nonmetric dental traits also play crucial role in ethnic classifications of a population that helps in forensic racial identification purposes.[8]

Aim: Evaluation and Comparison of metric & non-metric dental features amongst four major ethnic groups of Assam for Forensic Profiling.

Methodology: Total of 404 individuals included in the study with consent form primary impression is taken for both maxillary and mandible teeth. Cast are made and metric and non-metric analysis for 22624 teeth are done.

Results: The present study provides reference values for both metric and non-metric dental traits among Assamese populations in Northeast India, offering moderate utility in determining sex and ancestral background. The logistic regression analysis (LRA) accuracy for maxillary teeth was 63.40%, and for mandibular teeth, 61.10%. When both jaws were combined, the overall accuracy for sex determination reached 61.80%, suggesting it may serve as a useful adjunct to other skeletal parameters. Metric traits across maxillary and mandibular dimensions appeared uniform among different ethnic groups, showing no significant differences for sex or ancestry estimation. Non-metric traits revealed frequencies of 55.94% for shoveling in upper central incisors, 46.04% in upper lateral incisors, 22.03% for the Cusp of Carabelli, 54.21% absence of cusp 4, 23.27% absence of cusp 5 in lower first molars, and 90.35% absence of cusp 5 in lower second molars. Presence of cusp 6 (2.72%) and cusp 7 (12.62%) was also noted. These patterns closely resemble those seen in Northeast and Southeast Asian populations, predominantly of Mongoloid origin, while some features like the Cusp of Carabelli align with Indian traits. Although no significant sexual dimorphism was observed in non-metric traits overall, certain traits—such as shoveling, cusp of Carabelli, and cusp presence or absence—showed slight sex-related trends. Differences in non-metric traits among ethnic subgroups were minimal, with only shoveling and cusp patterns showing significant variation, though insufficient for ethnic differentiation. Given the absence of comparable data in the literature for these specific ethnic groups, this study stands as a novel contribution. While it may help in broadly identifying individuals as Assamese, it is not sufficient to determine specific ethnic affiliations within the population.

Conclusion: The study concluded that the This study provides baseline reference data on the frequency of metric and non-metric dental traits among Assamese ethnic groups, contributing to sex and ancestry estimation in forensic contexts. While moderate accuracy was observed in sex determination using metric traits (overall 61.80%), these alone are insufficient for conclusive identification. No significant inter-ethnic variation was found in tooth dimensions, and although certain non-metric traits—such as shoveling and cusp patterns—aligned with Mongoloid characteristics, they did not show strong sexual dimorphism or clear ethnic differentiation. Overall, while these traits can suggest Assamese origin, they are not definitive for distinguishing between the specific ethnic groups studied.

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INTRODUCTION

Northeast India, comprehand the modern states of Assam, Arunachal Pradesh, Manipur, Meghalaya, Nagaland, Mizoram, Tripura, & Sikkim, holds immense archaeological potential but remains a largely overlooked area of research concerning the country's material history.[2] Assam, in the middle of Northeast India, is surrounded and interspersed by mountains and hills. It is surrounded by Tibet in the north and Patkai hills (Arunachal Pradesh, Nagaland and Upper Burma region of Myanmar**)** in the Southeast with both the Brahmaputra and Barak Valley in the west.[1]Assam has many gateways for migration routes from Tibet, South-eastern China and Myanmar etc.[1] Some Neolithic sites in Northeast include those in Arunachal Pradesh, Sadiya, Dibrugarh, Lakhimpur, Nagaon, Naga Hills, Karbi Anglong, Kamrup, Garo and Khasi hills of Meghalaya, etc. The neolithic culture discovered in Assam has East and Southeast Asian affinities.[2] Unlike rest of India, North-east region inhabitant are an ethnic group of indigenous people from East Asia, Southeast Asia, and the North American Arctic.[3]

Forensic anthropology involves applying the methods and theories of anthropology, particularly biological anthropology, in a medico-legal context. Forensic anthropologists are typically consulted when remains are skeletonized, and the decedent's identity is unknown. The identification process begins with creating a biological profile, which generally includes estimates of the individual's sex, age, ancestry and stature. Estimating ancestry is crucial for identifying unknown individuals but poses challenges due to ever-changing genetic structures and evolving cultural definitions and perceptions. These challenges are further complicated by potential discrepancies between ancestry inferred from skeletal remains and an individual's self-identified race.[12]

The examination of dental morphological variation is a core focus within palaeoanthropology and more broadly, biological anthropology. For instance, global patterns of dental variation across geographic regions provide insights into the biological connections among human populations.[13] The dental morphology of both modern humans and fossil hominins has been extensively researched.[15-21]

The literature encompasses various aspects of hominin dentition, including metric variation, root morphology, and dental wear patterns.[22-24]

Human dentition is a complex system that begins developing in utero and continues to grow and mature into early adulthood.[25]It is widely accepted that the initiation and development of dental traits are predominantly governed by genetic factors during odontogenesis. However, the specific genes responsible for the presence or absence of particular dental traits remain largely unidentified. Twin and family studies suggest that genetics play a central role in tooth growth and development.[26-30]

Teeth offer valuable insights into a person's age, biological sex, and ancestral roots. Their unique traits often make them one of the most dependable indicators for personal identification.[4] Beyond cultural interventions like dental fillings, the features of teeth also involve their shape, count, overall health, placement within the mouth, and their spatial relationship to adjacent teeth. Furthermore, dental features differences can also be observed internally through the unique outlines of dental tissues and the distinct size and form of the pulp in each person.[4] Overall, teeth are essential in building accurate biological profiles and should be thoroughly considered in analyses involving human remains, particularly in forensic and bioarchaeological investigations.[4]

Dental features used to describe population differences are broadly categorized as metric (tooth size) and non-metric (tooth shape) features.[5]

Dental metric features such as measurements of tooth crowns serve as valuable data in fields such as anthropology, evolutionary biology, and forensic science.[6] Determining the sex of a deceased individual is a crucial, and often initial, procedure in forensic examinations. Among the most frequently utilized dental measurements for this purpose are the mesiodistal and buccolingual dimensions of teeth, which provide reliable indicators.[6] Males often exhibit greater crown dimensions compared to females, with the difference being particularly notable in canine teeth. Hence, dental metric features are one of the desirable items for human and gender identification.[6]

Non-metric dental traits are constant within a particular population which may be indicative of their inheritance. These morphological features remain stable due to high mineralized content of the tooth but it can become unstable if acted by an external agent (especially dental caries or other wasting disease).[7]

As Assam has served a gathering ground for people of various races, as a result, many distinct ethnic groups live there amongst which the four major groups are Kachari, Mising, Bodo & Deori.

There are no studies done on these ethnic groups regarding age estimation, gender determination and ethnic variance using metric & selected non -metric dental features. Therefore, region-specific dental data from Northeast India are essential to advance studies in forensic odontology and dental anthropology.[3]

AIMS AND OBJECTIVES

Evaluation and Comparison of metric & non metric dental features amongst four major ethnic groups of Assam for Forensic Profiling.

OBJECTIVE

1. To evaluate Metric features of tooth (Mesio-distal & Bucco-lingual dimensions) in people of Assam.

2. To evaluate the non-Metric features (Shovelling, Cusp4, Cusp5, Cusp6, Cusp7, Cusp of Carabelli) in people of Assam.

3. To compare the metric & non metric differences in the four major ethnic groups of Assamese.

4. To develop population standards that will facilitate the estimation of ancestry and/or gender of an unknown individual belonging to the population.

REVIEW OF LITERATURE

Northeast India, situated along one of the world's major migration routes, has been a significant centre of cultural development since ancient times. The earliest inhabitants of the region were the Australoid people, represented by the Khasis and Jayantias. Their Mon-Khmer language, still spoken by the Kols, Mundas, and Nicobarese of India, is also found in parts of Myanmar and Vietnam today.[31]

Following the Australoids, the Mongoloids or Tibeto-Burman language speakers migrated from western China. Research suggests that a group of Tibeto-Burmans once moved southward, splitting near northeastern Burma into two groups: one heading further south, and the other moving westward along the Himalayan foothills to Bhutan, Tibet, and Nepal. Over time, successive waves of these migrants entered Northeast India, settling in its hills and plains. These groups evolved into various ethnic communities, including the Garo, Rabha, Bodo, Kachari, Koch, Mech, Deori, Kuki-Chins, and Nagas.[31]

Linguistically, the Tibeto-Burmans are categorized into two main branches: the North-Assam and Assam-Burmese groups. Tribes from present-day Arunachal Pradesh, such as the Abors, Akas, Daflas, Miris (Mising), and Mishmis, form the North-Assam branch. Meanwhile, Assam-Burmese group includes the Bodos, Nagas, and Kuki-Chins.[31]

Most indigenous groups in Northeast India are part of various ethnic subdivisions traditionally associated with the Mongoloid lineage, that are related different heritage. These ethnic heritages are likewise present across regions of southwestern China and parts of South-east Asia. The Assam-Burma border, a convergence zone for diverse races, cultures, and languages from South and Southeast

Asia, is home to over a dozen distinct ethnic groups spread across the Patkai range. These include the Singphos (known as Kachin in Myanmar), Usus or Yobins, Tangsas, Noctes, Wanchos, Tutsas, Layos, Khamtis, Tai Phakes, Duanias, Shyams, Khamyasgias, Turungs, Bodos, Mons, Deoris, and others, with a combined population exceeding 100,000.[31]

Historical records indicate that these groups migrated from the subtropical hills and valleys of the Huang He, Yangtze, and Mekong River deltas, journeying downstream along the Salween and Irrawaddy rivers. Along their migration routes, they established settlements in various regions of Southeast Asia and Northeast India, resulting in shared social, cultural, and economic connections. Literary and archaeological evidence underscores the longstanding cultural interactions between Northeast India and Southeast Asia, tracing back to early times.[31]

Historically, Northeast India and Southeast Asia were linked through both land and maritime routes. Historical accounts highlight the existence of numerous migratory and trade pathways that facilitated connections between the two regions. This connectivity fostered cultural exchanges, creating a rich tapestry of socio-cultural influences. The Patkai range, with its various passes, served as a pivotal crossroads for interactions between the Indian subcontinent, the Southeast Asian peninsula, and Inner Asia.[31]

Among the many routes leading to China, the path through the Patkai pass to Bhamo and onward to China was the most frequently travelled. Records from Chinese envoys and pilgrims, such as Zhang Qian, Yijing, and Xuanzang, attest to the use of the Yunnan-Assam-Burma overland route, which linked Assam to China.[31]

The Khasis, who inhabit the eastern part of present-day Meghalaya, are regarded as one of the earliest ethnic groups to settle in the Indian subcontinent. The Ahoms, who migrated to the Brahmaputra Valley in Assam via the Patkai Pass in the early 13th century CE, are descendants of the Tai-Shan groups found across China, Myanmar, Laos, and Vietnam. Similarly, the Khamptis and Singphos maintained close socio-cultural ties with their kin in Burma.[31]

The Singphos, who migrated to Assam through the Patkai Pass, brought commodities like copper, silver, and tin from China via the Assam-Burma-China trade route. In Assam, these items were exchanged for silk, ivory, musk, madder, and other goods at markets in Sadiya. The Khamptis, along with the Tai-Phakes, Turungs, Aitaniyas, and Naras (Tai Khamyang), are small Buddhist communities that migrated from Burma to northeastern Assam in the early 18th century. The Khamptis settled along the banks of the Tengapani River near Sadiya, rising to prominence in the region by capitalizing on the unrest caused by the Moamariya rebellion. The Khamjangs, who controlled the Patkai Pass, entered Assam in the early 18th century to escape oppression by the Singphos. Other communities, including the Turungs, Aitons, Tangsa, Wancho, Tutsa, and Lisu, also migrated along the Patkai range and settled in the Brahmaputra Valley of Assam.[31]

Northeast India, located at the far eastern edge of India, the North Eastern Region (NER) holds significance as both a geographic zone and an administrative entity. This region includes eight states— Assam, Manipur ,Arunachal Pradesh, Meghalaya, Mizoram, Nagaland, and Tripura—commonly referred 'Seven Sisters,' along with Sikkim, which is frequently regarded as their 'brother' state.

The region shares a 5,182-kilometer (3,220-mile) international border, accounting for around 99 percent of its whole geographic perimeter. It borders China (1,395 km or 867 mi) to the north, Myanmar (1,640 km or 1,020 mi) to the east, Bangladesh (1,596 km or 992 mi) to the southwest, Nepal (97 km or 60 mi) to the west, and Bhutan (455 km or 283 mi) to the northwest. Covering an area of 262,184 square kilometers (101,230 square miles), the region makes up nearly 8% of India's total land area. It is connected to the rest of mainland India through the Siliguri Corridor.[32,33,34]

The earliest inhabitants of Northeast India are believed to have been Austroasiatic speakers from Southeast Asia, followed by Tibeto-Burman speakers migrating from China. By around 500 BCE, the region saw the arrival of Indo-Aryan speakers from the Gangetic Plains and Kra-Dai speakers from southern Yunnan and Shan State.[31]

Northeast India is home to a rich tapestry of ethnic groups, reflecting a diverse and complex cultural makeup . This is mainly due to diversity stems from the ancient influx of multiple ethnic communities migrating from neighbouring regions of East& Southeast Asia.There had also been raids and invasions by many invaders from Burma on the one side and from the Indian plains on the other. Such invasions left an abundant number of races, religions and languages. Consequently, this contributed Northeast India becoming a storehouse of nationalities. It can be easily inferred from the languages spoken or the myths created that the ancestors of many ethnic-tribal groups in the region hailed from far flung regions. A large number of tribal groups living in Northeast India are descendants of those who migrated here centuries ago from countries like- Mongolia, Tibet, China, Laos, Cambodia and Thailand. Therefore, this region can better be called a ‘Mongoloid India’ and culturally it is a part of the Southeast Asia. Northeast region of India serves as an ethnocultural bridge between the Indian subcontinent and its neighboring countries—China, Myanmar, Bhutan, and Bangladesh. Over time, the region has witnessed multiple waves of migration involving diverse ethnic communities. These groups are believed to have originated in the western regions of China, near the Yangtze and Yellow Rivers, and gradually moved southward beside the Brahmaputra, Chindwin, & Irrawaddy River system’s, eventually settling in parts of Northeast-India and present-day Myanmar.[32]

The population of Assam are broad-ranging racial blend of ancestries including Mongoloid, Indo-Burmese, Indo-Iranian, and Aryan lineages contributes to the region’s complex ethnic heritage. The hilly tracks of Assam are mostly inhabited by the tribes of Mongolian origin. The Assamese culture is a rich and exotic tapestry of all these races and has evolved over a long assimilative process. Native Assamese people are called "Asomiya", which is the same term used for their language.[35]

Assam is populated by many distinctive clan, each with their own customs, cultural practices, traditional attire, and way of life, coexist harmoniously within the region. Despite the wide use of Assamese language as the official language, each tribe speak their own. Following are some ethnic tribes of assam.[35]

Bodo

The Bodo Kachari’s of Assam are part of the larger Bodo branch within the Indo-Mongoloid ethnic family and are thought to trace their ancestral roots to regions in Tibet & China. The Bodo's basic occupation is agriculture and they still use traditional methods of farming and irrigation. [35]

The Mising (Mishing)

The Mising people, previously known as the Miris, are an Indo-Mongoloid ethnic community and represent the second largest tribal group in Assam. Their migration is believed to have begun in the 8th century when they moved into what is now Arunachal Pradesh, originating from northern regions near the sacred Lake Manasarovar. Eventually, they travelled along the tributaries that flow into the Brahmaputra River, settling in the fertile lowlands of Assam in pursuit of better economic opportunities. Traditionally, the Mising have followed animistic spiritual practices, rooted in nature worship and ancestral reverence. [35]

Sonowal Kachari's

Sonowal Kachari's are regarded as one of the historically significant royal lineages of Northeast India and form a prominent subgroup of the larger Bodo-Kachari ethnic community in Assam. Their primary settlements are found in the districts of Dhemaji, Lakhimpur, Tinsukia, and Dibrugarh. Additionally, smaller populations are dispersed across Sibsagar, Jorhat, Golaghat, the neighboring states like Nagaland & Arunachal Pradesh. The Sonowal Kacharis belongs to the Mongoloid race of people.[35]

Deori

Deori community traditionally resides along the banks of the Brahmaputra River, with a significant presence in the states of Assam, Nagaland, and Arunachal Pradesh. They communicate in their native tongue, Deori, which belongs to the

Tibeto-Burman language family. The Deori are unusual in that they have managed to maintain their tribal identity by keeping themselves free from racial intermixture and intermarriage with other Bodo tribes.[35]

Forensic Data and Research in Northeast India:

Northeast India is home to numerous ethnic groups with distinct genetic, physiological, and cultural characteristics. The region has historically lacked the necessary forensic laboratories, equipment, and facilities required for conducting advanced research and studies. This shortage hinders the generation of forensic data and the ability to carry out specialized forensic research in areas like DNA analysis, toxicology, and forensic pathology.[55] There is a shortage of professionals with specialized forensic training in Northeast India. Many forensic fields, such as forensic odontology, digital forensics, and forensic anthropology, require highly skilled experts, but the region lacks educational institutions or training programs that focus on these fields. As a result, there is a gap in the availability of qualified personnel to conduct research[55].Forensic science is still developing in India, and many regions, including Northeast India, have not fully recognized its importance in criminal investigations, public health, and disaster management. Without proper awareness of its value, there is less incentive to conduct forensic research or to focus on producing forensic papers. Forensic research requires access to a substantial amount of data, which can be difficult to collect due to logistical, legal, and ethical barriers. In a region with a diverse population and complex socio-political issues, obtaining reliable data for forensic studies can be challenging. Northeast India's geographic location and political context sometimes result in a sense of isolation from the rest of the country. The region may not always have the same academic and research opportunities as other parts of India, leading to fewer initiatives in forensic science and research publications.[55]

Northeast India is in dire need of research in forensic genetics, anthropology and odontology that could help address the challenges in identifying individuals and solving crimes within these diverse communities. The region is prone to natural disasters such as floods, earthquakes, and landslides [56] Forensic research is crucial in the aftermath of such events, where identification of victims may rely on advanced forensic methods like DNA analysis, dental records, or fingerprint analysis. Research can enhance the region's ability to effectively respond to mass casualty situations and ensure the timely identification of victims.[56] As crime rates increase in the region, there is a growing need for advanced forensic techniques to investigate and solve criminal cases. Research in forensic science can help improve the accuracy and reliability of evidence analysis in cases of murder, assault, sexual violence, and other crimes. It can also provide valuable data to inform policy-making, legislative decisions, and the development of regional forensic protocols. It can also help in the drafting of laws related to forensic investigations, evidence handling, and criminal justice in Northeast India.[56]

Assam has a highly diverse population, with various ethnic groups that may have distinct dental characteristics. Forensic odontology can help identify individuals based on their unique dental features, especially in cases where traditional methods like DNA or fingerprint analysis are not feasible. Understanding the regional variations in dental traits can improve the accuracy of identification methods in Assam.[57]

Assam is vulnerable to natural disasters such as floods, earthquakes, and landslides, which can lead to mass casualties and the need for rapid identification of victims. Forensic odontology plays a crucial role in these situations by helping identify individuals through dental records when bodies are too decomposed or damaged for other identification methods. Research and development in this field would better equip Assam to handle such emergencies.[57]

As crime rates, including cases of assault, abuse, and murder, increase, forensic odontology can be a valuable tool in investigations. Bite mark analysis, dental evidence in cases of assault, and the identification of unknown victims through dental records are all areas where forensic odontology can aid in solving criminal cases. Exploring this field can improve the overall effectiveness of the criminal justice system in Assam. Assam faces a shortage of forensic experts and infrastructure to handle complex forensic cases. Establishing a strong base in forensic odontology would help build local expertise, improve the capacity of forensic laboratories, and create a network of professionals skilled in handling dental evidence. This would also reduce the dependency on external experts for forensic investigations.[58]

Assam, with its proximity to international borders and socio-political issues, experiences challenges related to human trafficking and missing persons. Forensic odontology can play a crucial role in identifying victims of trafficking or those found in abandoned or unidentified conditions. Research in this area can help develop more efficient methods for identification in such cases. Forensic odontology is a vital area of research that needs to be explored in Assam to address the region's unique challenges related to crime, disaster management, victim identification, and public health. By developing expertise in this field, Assam can improve its forensic capabilities, enhance its criminal justice system, and better respond to emergencies and mass casualty situations.[58]

Forensic Odontology and its Applications

Forensic odontology is the application of the art and science of dentistry to the legal system.[105] Many have attributed to the establishment of forensic odontology as a unique discipline in itself; the "father of forensic odontology" is Dr. Oscar Amoedo, who identified victims of a fire in Paris in 1898.[106]

Modern forensic odontology has many established applications:

1. Various unique features of the dentition can be used to potentially identify a deceased individual. Post-mortem dental data are compared with ante-mortem dental records of the unknown individual in order to potentially establish their identity.[107] Dental identifications are especially important in mass disaster scenarios involving considerable fragmentation of the remains; the teeth may be the only element left for identification purposes. Dental DNA analyses are also important for establishing identity; Enamel ranks as the most durable and mineralized substance within the human dentition and this makes teeth inherently resistant to damage. This protects the mitochondrial DNA inside the teeth and thus provides a reservoir of genetic material.[105,108]
2. Patterned tissue injuries produced by the dentition (bite marks) or biting patterns produced on non-living substances (e.g. food) can be compared to a dental impression of a suspect. Bite marks are also a potential source of DNA.[109]
3. Forensic dentistry also encompasses cases of dental malpractice where the standard of dental care provided to a patient by a dental practitioner is

analysed.[105]

4. Other techniques used in forensic dentistry include rugoscopy (study of palatal rugae pattern) and chieloscopy (study of lip prints) for the purpose of establishing identity (e.g. linking a suspect to a scene where trace evidence is present.[106]

Another important role of the forensic dentist towards establishing personal identity is the formulation of a post-mortem dental profile, which can be used to reduce the available pool of potentially matching profiles. This involves estimating sex, age and ancestry on the basis of morphological characteristics (either metric or non-metric) present in the dentition.[110]

A specific emphasis is placed on the use of dental anomalies for identification purposes. It has been well documented that dental anomalies occur at different frequencies within various populations and between sexes.[111.112] Such data can be useful for appointing an unidentified person to a particular sex, age group or ancestry. Despite this, there has been limited research examining the potential of estimating these biological features based on how frequently dental anomalies seen; a selection of the available studies is, however, accordingly reviewed in this section.

In a global era of criminal activity, terrorist attacks (e.g. World Trade Centre) and natural disasters (e.g. South East Asian Tsunami), forensic odontology has become inextricably involved in the investigations of such events. It is now a vital element in Disaster Victim Identification (DVI), but unlike fingerprint identification that requires particular concordant points, a positive dental identification can be made on the basis of a single dental feature.[113]

DNA identification in mass catastrophe cases is often problematic because it is expensive and requires specialized equipment. Severely decomposed tissues and sample contamination are other confounding factors.[115] The various advantages and limitations of different identification methods must be assessed on a case-by-case basis, but a multidisciplinary approach is generally considered the most appropriate in scenarios involving death on a mass scale.[114]

In anthropology, forensic science, and genetics, teeth are useful tool that provide information about both live people and historical or ancient artefacts.[47] Teeth are among the most well-preserved tissues in the human body, largely due to the strength of enamel—the hardest biological substance we have. This exceptional durability allows teeth to withstand extreme heat and survive the effects of fossilization over time, including exposure to varying environmental conditions, pH levels, moisture, salts, and trace elements.[48] Because of this, in many forensic investigations and archaeological digs—where complete skeletal remains are rarely recovered—teeth and skulls frequently serve as the primary sources for identifying individuals.[49]

These distinctive traits make it possible to distinguish individuals from various cultural or ethnic backgrounds. Even when a person's identity is unknown, their unique dental morphology can help accurately associate them with a specific ethnic group.[50]

Tooth morphology in human identification:

Differences in tooth shape and structure are highly significant in dentistry, dental anthropology, and evolutionary studies. These variations are generally categorized into metric traits, which involve measurable dimensions, and non-metric traits, which are more qualitative in nature. The diversity in tooth form and size across populations of different ethnic and geographic backgrounds holds considerable value in anthropological research. Such characteristics aid in recognizing racial and ethnic patterns and play a crucial role in identifying individuals in forensic investigations.[37]

Non-metric traits represent independent, neutral variations in dental morphology. These features are valuable in tracing patterns of shared ancestry, human migration, and genetic exchange between populations.[38,39,40]

Teeth are remarkably durable, capable of withstanding decay, environmental damage, fire, and the passage of time. Because of this resilience, they can reveal valuable information about an individual's ethnic background and biological sex. Additionally, teeth provide insight into ancestral origins, migration patterns, and even the dietary habits of past populations.[41,42,43] Among the many biological differences observed in human populations, non-metric dental traits play a crucial role for researchers investigating the connections between biological history and physical appearance. Dental anthropology is especially valuable in studying human variation due to several key advantages. These include the presence of numerous independently inherited traits, the excellent preservation of teeth over time, and their evolutionary stability—largely unaffected by natural selection. Additionally, these traits are genetically determined, show significant variation between populations, and can be easily studied in both living individuals and fossilized remains. [37,38,44,45,46]

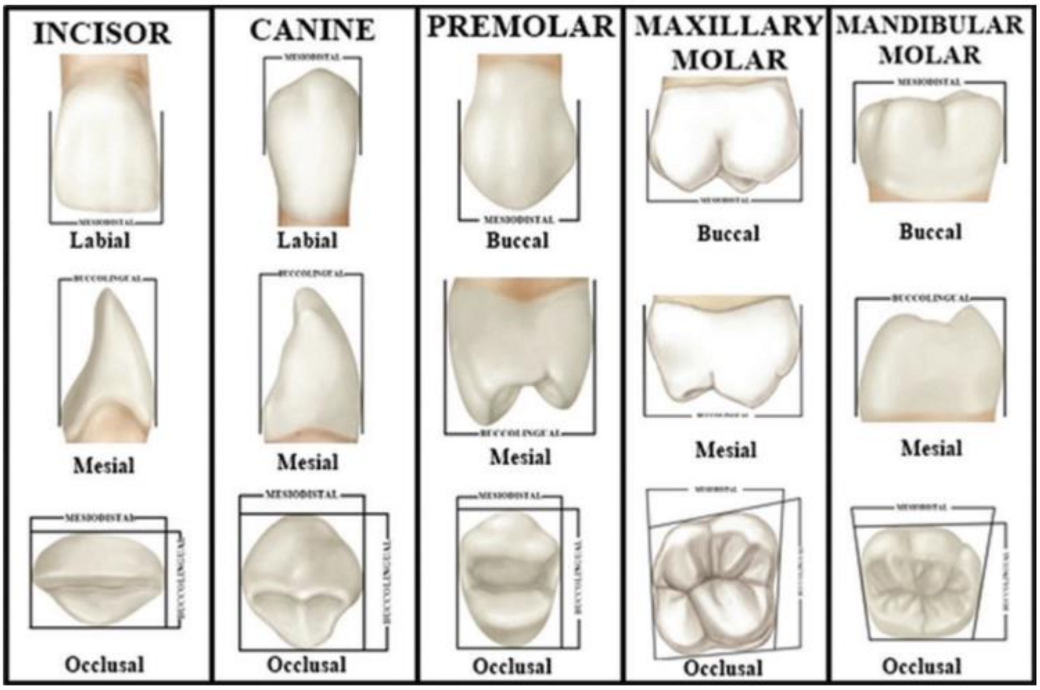
Teeth provide valuable insights into the extent and nature of diversity within human populations. Even among groups living within the same geographic region, variations in dental crown size have been observed.[51] Differences in tooth shape are common in permanent teeth and are vital for studies in ethnicity, forensics, and anthropology. Factors such as heredity, ethnicity, biological sex, and evolutionary patterns play a significant role in determining tooth size variations across different groups and populations.[52]

The physical measurements and shapes of teeth can offer key details about a person’s age, gender, ancestry, social standing, lifestyle, and both oral and general health. They can also help indicate a person's profession and the quality of their diet.[53]

Odontometry, an anthropological field that emerged in the early 1700s, focuses on analyzing dental characteristics to distinguish between various groups and populations.[54] Odontometry is essential in forensic dentistry for identifying individuals and also contributes to treatment planning in clinical dentistry.[54]

In the analysis of morphometric traits, the mesio-distal (MD) & bucco-lingual (BL) measurements, excluding the 3rd molar’s, were recorded on dental casts. The measurements were carried out using digital calipers, offering a precision of 0.01 mm ‘Mitutoyo Corp., Kawasaki, Japan; Altraco Inc., Sausalito, USA’.[61] The measurements like MD are determined as the maximum distance between the contact points on the crown's proximal surfaces. These were taken with a caliper beak’s positioned occlusal side, aligned along the tooth’s long axis.[59,60]

Figure1: Measurement of tooth crown dimensions[53]



Measurements were made at the locations on the crown's proximal surfaces where contact with nearby teeth would normally occur if the teeth were misaligned or rotated.[60] Even though this criterion was strictly adhered to, the measurements were essentially the caliper's maximum practicable access, which might not match the tooth surfaces' anatomical crest of curvature. Caliper beaks for (MD) dimension held at right angles as previously mentioned, the (BL) measurement was determined as the distance between which is maximum the tooth crown's lingual surface and labial/buccal surface.[59,60]

Dental morphology is used to ascertain sexual dimorphism known for a procedure based in the field of anthropology and biological investigation; especially in forensic odontology, it determines sex from fragmented jaws and dentition.[49] Buthz and Ehrhardt demonstrated in 1938 that measuring the crowns of permanent teeth may be used to determine the degree of sexual dimorphism in human teeth.

In general, male teeth have been found to be larger than those of the female. Nevertheless, these studies came to the conclusion that the size differences were not sufficiently different to provide a trustworthy sex determination.

Forensic identification and analysis of metric features

A forensic DVI team rarely works with complete and/or undamaged human remains. Prior to any attempt to establish a positive identification, the available pool of potentially matching identities must be reduced; this is typically achieved by formulating a circumstantial ID. This is essential in the case of mass death scenarios as well as in routine criminal cases involving unknown human remains. [116]

A circumstantial identity is established by formulating a biological profile (sex, age, ancestry and stature); the last attribute is obviously estimated using non-dental elements. Individuals who do not have the same biological attributes can then be excluded as a possible matching identity.[117] When a circumstantial identification has to be established, some unique features present in the skeleton and dentition, including anomalies and pathological conditions, may also provide important information that can lead to the establishment of a positive identification of the deceased.[118]

The following is a brief introduction on how sex, age and ancestry can be estimated on the basis of dental metrical analyses.

i. Sex

Sex estimation is an important element of the biological profile as it narrows the pool of potentially matching identities by eliminating members of the opposite sex. [119] Sexual dimorphism in the skeleton and the dentition occurs under the influence of sex hormones.[121] There are differences in the size, shape and form of teeth in males and females within the same population, although the degree of sexual dimorphism in the teeth may vary between different populations.[81,71,121,122]

Metric methods (odontometrics) involve taking measurement between various defined anatomical features in the jawbones and teeth, which are then statistically analysed. Odontometric approaches have traditionally been used for estimating sex and age.[123,124]Fine point vernier or digital callipers are used to measure a tooth; the most common measurements taken are the bucco-lingual, mesio-distal and occluso-cervical (crown height) dimensions. Significant size differences have been quantified between male and female teeth; the former being larger. Sex differences in tooth dimensions are known to be population specific [81], such data is, however, useful for estimating sex in individual identification cases, as well as mass death scenarios.[49,81,125,126] The mandibular canine is often said being predominant sexually dimorphic tooth in the human dentition.[67]

ii. Age

Metric analysis of the dentition for the estimation of age can be performed by quantifying the degree of secondary dentin deposition (pulp/tooth ratio). Kvaal et al. demonstrated that the age-related changes in teeth can be evaluated from radiographs. The authors examined full mouth radiographs of 100 individuals aged between 20 to 87 years and selected six teeth for assessment, from either left or right side (no bilateral variation in secondary dentin deposition found). They are predominantly radiographic methods and are beyond the scope of the present thesis, however, to review them here.[127]

i. Ancestry

The estimation of ancestry using dental metrics generally requires the application of discriminant function standards; the basic premise is that individuals of a certain ancestral background have significantly different tooth dimensions. One such example is Hanihara & Ishida, who assessed each person's buccolingual and mesio-distal dimensions the teeth in 72 major human populations, which comprised 7 major geographical groups (East Asia, North- East Asia, South-East Asia, Arctic, North America, Central/South America, Australia and South Asia). Hanihara and Ishida (2005) confirmed the split of recent and modern populations into microdontic (Philippine, Western Eurasian), mesodontic (Asian, Indian subcontinent, sub-Saharan African) and megadontic (Australian) groups. They also concluded that odontometric variations are efficacious for assessment of patterning amongst contemporary human populations globally.[128]

Logistic regression has also been applied to dental metric data to estimate ancestry[50], Edgar et al described eight dental characteristics that were useful to differentiate between people of African-American and American-Caucasian ancestry, with up to 90% expected accuracy.[129] Matis & Zwemer showed that discriminant function analyses could be used to effectively differentiate between American Indians and Inuit individuals with an expected classification accuracy of 90%.[130] A selection of research papers is accordingly reviewed below.

Table1: Metric parameters with sex determination accuracy in different studies.

Author	Population	Maxilla Accuracy	Mandible Accuracy	Sex Determination Accuracy	Parameters
Rani et al[75]	Mysorean Indian	78.8%	0%	66-78%	BL (All teeth except 3rd molars)
Wankhede et al[77]	Ahmednagar, Indian	69%	66%	68%	BL (All teeth except 3rd molars)
Yadav et al[78]	Indian	0	0	62.70%	MD and BL dimensions all teeth except 3rd molars
El dosoky et al [79]	Egyptian	74-78%	0	72-75%	MD and BL dimensions all teeth except 3rd molars
Eboh et al[80]	Uuhobo, south nigeria	69%	0	69.00%	MD and BL dimensions for First Maxillary Molar (FM) and Second Maxillary Molar (SM)
Iscan et al[81]	Turkish	77%	75%	73-77%	BL dimensions all teeth except 3rd molars
Acharya et al[82]	Nepalese	88.70%	84.90%	92.50%	MD and BL dimensions all teeth except 3rd molars
Zorba et al[83]	Greek	74%	65.50%	81.80%	MD and BL dimensions for Maxillary and Mandibular First & Second Molar
Khamis et al[157]	Malaysians	71.5%	76.5%	78.5%	MD and BL dimensions all teeth except 3rd molars
Iqbal et al[156]	Chinese	0	76.8%	76.8%	MD (36,46)
Adams et al[158]	Japanese	70-75%	70-80%	77.3-80.3%	MD, BL of 11,21,14,24,32,42,34,44,36,46
Franco et al[84]	Portuguese	0	69.50%	69.50%	MD (36,43)
Punnya VA et al[61]	South Indian	68.8%	74%	74.8%	MD and BL dimensions all teeth except 3rd molars
Acharya et al[68]	Nepalese	0	69.10%	69.10%	MD (33,43)
Rishab Kapila et al[69]	South Indian	0	90%	90%	MD (33,43)
Kaushal et al[70]	North Indian	0	75%	75%	MD (33,43)
Acharya et al [71]	Indian	0	65.70%	65.70%	MD (43)
Kazzazi et al[72]	Iranian	87.1%	78.4%	78-87.10%	MD, BL of Maxillary and mandibular 1st & 2nd molar
More et al [73]	Indian	64%	66.2%	65.25%	MD&BL (16,26,36,46)
Soundarya et al[76]	South Indian	81%	72%	81%	BL&MD of maxillary and mandibular central incisors, canines, first molars
Narang etal[74]	North Indian	67.5%	88%	67.5%-88%	MD&BL (16,26,36,46)

Non-metric dental traits and the biological profile

Non-metric dental features can be assessed for their presence and degree of expression amongst various populations; they are readily definable and relatively easy to score.[131] These features can be assessed visually and thus do not require any special equipment for their assessment. An important benefit, however, is that unlike metric methods, non- metric traits can be analyzed in fragmentary remains.[132] With recent advances in the field of genetics, it has been proven that various traits have unique pattern of inheritance and hence can be predictably present in various individuals belonging to a particular population.[133] It is well documented that frequencies of various non-metric skeletal and dental traits vary in certain populations due to genetic variations.[63] It has also been suggested that cranial and dental non- metric traits are more useful than post-cranial features for studying population differences as they are more closely related to environmental and functional influences compared to post-cranial traits.[135]

The number, structure, shape size and eruption of teeth are highly affected by environmental factors such as infections, hormones, nutrition, drugs and chemicals, the amount of fluoride in the drinking water, as well as by functional factors including dietary habits and the type of food consumed.[5,135] A potential limitation in using non-metric dental standards is that the data is often not statistically quantified and thus lack statistical rigor.[118] A non-metric dental trait is usually assessed based on its frequency in a particular population group. If a trait is found to occur with a high frequency in a particular population, it is accordingly considered to be a representative trait of that particular population.[131]A thorough understanding of the world-wide distribution of various non-metric dental variations, along with an understanding of their pattern of inheritance, is thus necessary to enable a forensic odontologist to attempt to estimate sex and ancestry using the dentition.

Various global populations have differences in the frequency of occurrence of dental abnormalities and anomalies that may be useful for estimating sex or ancestry. A number of studies have been performed to quantify the frequencies of dental anomalies in different populations. Various morphological characteristics of teeth are specifically present in certain population groups and can be used to differentiate ethnicity affiliations of an individual. Dental characteristics include the curves, bulges, cusp pattern, cusp frequency, cusp position, groove pattern, number of roots, number of teeth, bends, furrows, joining (linkage), that appear in various sizes, shapes on the crown and root for assessment of ethnicity.[62]

Dental anthropologists have classified human dental variations (non-metric dental traits) into two basic types; the first type features involve major deviations (dental anomalies) from the normal dental blueprint (e.g., extra tooth or fused teeth). The other types of dental variation are minor and more delicate ones that involve variation in secondary cusps, fissure patterns, and supernumerary roots (amongst others).[63]

The various unique characteristics/features associated with the human dentition are those which can be visually recorded from the teeth. The dental anomalies can be in the form of the defects, abnormalities of the size, shape, numbers, structure, eruption, or position of the teeth. The arrangement, shape, and structure of the teeth in the dental arches provide unique information that may be unique to a person. Subtle variations in tooth position and shape can be utilised to differentiate identical twins based on their dental traits.[64]

Therefore, dental anomalies are special features of the teeth which are helpful in distinguishing and identifying the sex and ancestry of an individual. Dental anthropologists have been studying the dental variations since the 19th century as they are more common and vary within and between populations, and thus, are largely considered to be useful in evolutionary and forensic contexts.[62]

Numerous non-metric dental variations have been reported within the last century. Their evolutionary importance and functional roles have been investigated by numerous researchers.[28,63]

More than 30 non-metric traits of the tooth crown and root have been described and analyzed in detail by Scott and Turner. Data exist for Indians for only a few features and these have been obtained from the preliminary studies of Vijapure and coworkers, and Angadi and Acharya, on a sample of 105 heterogeneous subjects.[65] The following is a description of these traits:

The development of ‘mesial and distal’ marginal ridges along the inner (lingual) surface maxillary and lower front teeth are referred to as "shovelling.". The marginal ridges may be absent, slightly developed or very prominent. The lingual fossa is a secondary reflection of marginal ridge development. The maxillary central incisors are the recommended teeth for observing the trait in assessing population differences. Virtually 0% shovelling was found in the preliminary heterogeneous Indian sample .[5]

Carabelli’s cusp, or tubercle of Carabelli, is where the mesiolingual or lingual aspect of the mesiolingual (mesiopalatal) cusp of maxillary molars is where the derivative is expressed. It could be missing or manifested as well-developed tubercles with free apexes or little depressions. For assessing population differences, the maxillary first molar is examined. According to reports, it affects 26% of Indian people.[5]

Cusp 4/Maxillary second molar with three cusps: The distolingual (or distopalatal) cusp is usually seen on the first maxillary molar, while it is frequently absent or only slightly present on the second molar. In India, 34% of people have the maxillary second molar's three-cusped feature.[5]

Winging: This crown characteristic is indirect. It is distinguished by the distal edges of the maxillary central incisors rotating bilaterally labially. When the incisal edges of the central incisors are combined, the occlusal aspect gives the impression of a "V." In 16% of the Indian population, winging was noted.[5]

Cusp 5: This is characterized by the presence of occlusal tubercles on the distal marginal ridge of maxillary molar(s), particularly the first molar. An incidence of 75% is observed in Indians.[5]

Cusp 6: An additional cusp between distal and distolingual cusp of mandibular molar(s), particularly the first molar, is referred to as cusp 6. Approximately 57% of Indians have been shown to exhibit this feature.[5]

Cusp 7: An additional cusp expressed between the lingual cusps of mandibular molar(s), particularly the first molar. It appears wedge-shaped from the occlusal aspect, with the base of the wedge placed lingually and apex towards the central pit. The feature is observed in just over 21% of Indians.[5]

Matsumura (1995) examined the population relationships between East Asians, Southeast Asians, Native Americans, and Australian Aborigines using 21 non-metric features. The study demonstrated the formation of separate subgroups among Arctic peoples, Native Americans, and Northeast Asians. These subgroups belonged to a broader cluster that most likely started in Asia's northeast. It was evident that this cluster was distinct from another that had Melanesian and Australian populations.[66]

Hanihara used observations from Japanese, Ainu, and American Indians to define the "Mongoloid dental complex.[102] Brues describes 'Mongoloid' as a word that includes East Asian native populations. The Chukchi in the north, the Malays in the south, the Japanese in the east, the Burmese in the extreme west, and the majority of Southeast Asian islanders are all included in this. Additionally, it includes every indigenous group in these areas.[103]

Turner CG explained dental patterns like Sinodont, Sundadont, and other related dental types, which are patterns of dental morphology used in anthropology to trace population movements and genetic relationships.[94]

Sinodonty is characterized by a specific set of dental traits, including: Shovel-shaped incisors, High frequency of double shovelling, Reduced or absent third molars, Complex root patterns with multiple canals. This dental pattern is primarily found in Northeast Asians, including populations from China, Mongolia, Korea, and Japan. It is also observed in Native Americans, suggesting a link through ancient migration from Asia across the Bering Strait.[94]

Sundadonty represents a different dental pattern with: Less pronounced shovelling of incisors, simpler molar cusp patterns, lower occurrence of double shovelling. It is typically associated with Southeast Asians, including populations from the Philippines, Thailand, and Indonesia. This pattern is considered more archaic, potentially representing the dental morphology of early modern humans in Southeast Asia.[94]

Indodont refers to the dental pattern found in South Asian populations. It appears to share some characteristics with both Sinodont and Sundadont patterns, with region-specific traits that reflect gene flow and intermixing.[94]

Australomelanesian Dentition which are found in Australian Aboriginals and Melanesians.

Key features are large, robust teeth, simplified crown morphology. This pattern reflects the dental characteristics of early human populations in the region.[94]

Arctic Dentition are associated with Inuit and Aleut populations. Key traits are heavy dental wear, large, robust molars, adaptations for cold-climate diets.[94]

Kalistu et al highlighted traits commonly used for racial identification globally are based on findings from Scott and Turner, Irish, and Bailey [28,172,16]. When a particular trait is consistently found within a specific race, it is described as having a high frequency for that group. If the trait appears at an average rate, it is considered to occur with moderate frequency, and if it is less commonly observed, it is said to have a low frequency within that race.[171]

Kalistu et al highlighted various nonmetric dental traits and their frequency across different racial groups—Mongoloids, Negroids, and Caucasoids. In Mongoloids, several traits occur with high frequency, including shovelling and double shovelling of incisors, the presence of a 5-cusp molar with Y grooves, protostylid, supernumerary teeth, winging of maxillary central incisors, and deflective wrinkles. These features are commonly found in this population. Negroids, on the other hand, exhibit a high frequency of the Bushman canine/mesial ridge and two-rooted maxillary first premolars. Meanwhile, Caucasoids frequently display the Carabelli cusp, crowding of teeth due to a smaller jaw size, and peg-shaped teeth, which are often observed as smaller and more pointed lateral incisors.[171]

In Mongoloids, moderate frequency traits include the presence of a 7-cusp molar with Y grooves and some degree of dental crowding. Among Negroids, the 5-cusp molar with Y grooves appears with moderate frequency. In Caucasoids, traits such as shovelling and double shovelling of incisors, 7-cusp molars with Y grooves, winging of maxillary central incisors, and two-rooted maxillary first premolars are observed at a moderate rate.[171]

In Negroids, most traits appear infrequently, including shovelling, double shovelling, Carabelli cusp, 5-cusp with Y grooves, protostylid, supernumerary teeth, crowding of teeth, winging of maxillary central incisors, peg-shaped teeth, and deflective wrinkles. Similarly, in Mongoloids, low-frequency traits include the Bushman canine/mesial ridge, Carabelli cusp, and peg-shaped teeth. In Caucasoids, traits such as protostylid, supernumerary teeth, and deflective wrinkles are rare[171]

These dental traits help in distinguishing racial groups based on morphological variations in teeth.[171]

Our research also includes 7 non-metric traits- Shovelling, Carabelli’s cusp, Cusp4 (Hypocone absence), Cusp5 (Hypoconulid absence), Cusp6(Entoconulid) and Cusp7(Metaconulid).

The following studies are also not necessarily forensically based projects, although they have clear potential medico-legal applications, and represent the closest related literature to the present research thesis. Most of the studies reviewed aimed to depict differences in the frequency of selected dental anomalies amongst various ethnic groups within a given population.

Table 2: Non -metric parameters in different studies determining ancestry

S.No	Author	Trait	Racial Population	Identification points
1	B.Keerthana et al[65]	'Cusp of carabelli, talon's cusp, shovelled incisor, and peg shaped lateral incisor, protostylid, dryopithecus groove pattern, hypoconulid, parastyle, bushman canine, interruption grooves.'	South Indian	Higher prevalence of the Cusp of Carabelli and Shovelled Incisors are seen, which aligns with European and Asian populations.
2	Sharon et al[86]	Winging,Shovelling,Double shovelling,Reduced/peg-formedtooth, Interruption groove,Carabelli'scusp, Deflectingwrinkle, Reduction of the hypocone, Metacone, Protostylid,Entoconulid, Metaconulid,Pegshaped molars, Premolar lingual cusp variation, Bushman canine	Mediterranean, Nordics, Oriental Mediterranean, Proto-australoid	1.Mediterranean population showed a higher frequency of deflecting wrinkle, which is more typical of Middle Eastern and Mediterranean groups. 2. Nordics showed higher frequencies of metacone and protostylid, which are more common in Caucasian populations. The Carabelli's trait, frequently seen in European populations, was also prevalent. 3. Metacone prevalence is consistent with Asian populations, indicating genetic ties with East Asian or Mongoloid groups 4. The high prevalence of premolar lingual cusp variation is consistent with Australoid groups.
3.	Deepak V. et al[87]	WINGING, SHOVELLING, DENTAL TUBERCLE, CUSP OF CARABELLI, HYPOCONE	Hinduism, Islam, Christianity and Iranian	1.Winging 82% and shovelling-84% expression in Iranians aligning with Mongoloid populations. 2.Islams showed Hypocone absence is 88-

				89% is frequent in Mongoloid and East Asian populations. 3. Carabelli's trait expressed high in islams & christians is common in European populations (especially in Caucasians).
4.	Srivastav M et al[88]	'Cusp of carabelli, talon's cusp, shovelled incisor, and peg shaped lateral incisor, protostylid, dryopithecus groove pattern, hypoconulid, parastyle, paracone, bushman canine, interruption grooves, tuberculum dentale.'	Tamil	Significant frequencies were cusp of carabelli (23%) shovelled incisor (8%). The Tamil population shows a lower prevalence of shovelling and Carabelli's trait compared to Chinese, Saudi Arabian, and Mongoloid populations but a higher prevalence of peg lateral incisors compared to Greek and Asian populations
5.	Vaishali et al[89]	Cusp-Number,Cusp 1/Protocone/Carabelli's Trait, Cusp 3/Metacone,Cusp 4/Hypocone,Cusp 5/Metaconule (Maxillary),Cusp 5/Hypoconulid (Mandibular),Cusp 6/Entoconulid/Tuberculum Sextum,Cusp 7/Metaconulid/Tuberculum Intermedium,Groove Pattern,Parastyle,Protostylid , Premolar lingual cusp variation, Shovelling	Vidarbha, Maharashtrian	1.The Vidarbha population shows a higher prevalence of Carabelli's trait, shovelling, and protostylid compared to other Indian populations. 2.The higher prevalence of Cusp 5, cusp 6 is 5-15%, cusp 7 is 10-25% and protostylid indicates ancestral traits, suggesting possible genetic continuity with ancient South Asian populations.
6	Pillai et al[90]	Maxillary Incisor Labial Curvature, Maxillary Incisor Shovel shape, Maxillary Incisor Tuberculum Dentale	Gujratis	Shovelling of incisors: Seen in 18.2%.Carabelli's cusp: Present in 15.7%.
7.	Baby et al[8]	Traits in Premolar- Mesial accessory ridge, Distal accessory ridge,Tuber apex , Terra, Tricuspid upper premolars,Hypostyle,	Kerala	1)The Kerala population shows a lower prevalence of Carabelli's trait compared to Saudi

		Paracone, Vestibular sulcus, Central ridge, Distolingual groove, Lingual cusp number >1, Groove pattern, Double shovel, Odontome, Uto-Aztecan upper premolar, Root number,Tome's root ,Radicals. Traits in molars- Carabelli trait,Parastyle,Metaconulo, Hypocone,Hypoconid reduction, Metacone, Dryopithecus groove pattern, Elbow crease, Protostylid, Cusp 5,Cusp 6, Cusp 7, Taurodontism ,Deflecting wrinkle, Distal trigonid crest, Enamel extensions, Root number ,Radicals.		Arabian, Chennai, and Bangalore populations, which is characteristic of Asian populations 2)The lower prevalence of Cusp 5 is 7.91%, cusp 6 is 1.19% and cusp 7 is 0 suggests ethnic differentiation from Colombian and Caucasian populations.
8.	Luisa et al [91]	Carabelli trait, Protostylid, Groove pattern,	Colombian	High frequency of carabeli trait and groove pattern suggest a mix of Mongoloid and Caucasoid influence.
9.	Sah Sk et al[92]	Cusp of Carabelli, Shovelling	Indo Nepalese,Tibeto-nepalese	High % of Carabelli's cusp in Indo-Nepalese population and more prevalence of shovelling in Tibeto-Nepalese.
10	Peiris HRD et al[93]	Winging,Shovelling,Double-shovelling, Interruption groove, Lingual cusp variation,Cusp of Carabelli, Hypocone,Cusp number, Y groove pattern, Deflecting wrinkle, Protostylid,Cusp6, Cusp7	Sri Lankan Vedda population	While shovelling, double shovelling in the maxillary central incisor, and deflecting wrinkle in the mandibular first molar had the lowest frequency (0%), cusp 5 present in LM1 is 41%, LM2 is 2%, cusp 6 is 40%, and cusp 7 is 41%. The highest frequencies were recorded by cusp number in the mandibular second molar (95.9%) and hypocone absence in the maxillary second molar (93.8%).
11	Turner CG et al[94]	'Winging, Shovelling ,Double Shovelling,Interruption Groove,Tuberculum Dentale,Mesial-Ridge,Distal Accessory Ridge,Hypocone,Cusp5 ,Carabelli Trait,Parastyle ,Enamel Extension, Root Number,Peg/Reduced/Congenital Absence,Lingual Cusp Number	Northeast Asians (China, Japan, Mongolia, Siberia, and Native Americans)	Marked by high UI1 shoveling (73.5%–88.3%), moderate UI1 double shoveling (24.2%), moderate UI1 winging (21.9%–34.3%), and UM2 hypocone absence (66.7%). Other traits include moderate

		,Groove Pattern, Cusp Number ,Cusp-Number,Deflecting Wrinkle, Distal Trigonid Crest ,Protostylid , Cusp 7, Tome's Root'		UM1 cusp 5 (23.3%), UM1 Carabelli trait (30.9%), and LM1 deflecting wrinkle (20.4%), while LM2 four cusps (13.6%–19.5%), LM2 Y-groove pattern (16.1%–20.2%), and LM1 cusp 7 (7.9%–11.8%) are low, with high UI1 shoveling and low LM2 four cusps being key **Sinodont traits.**
12	Turner CG et al[94]	'Winging, Shoveling ,Double Shoveling,Interruption Groove,Tuberculum Dentale,Mesial-Ridge,Distal Accessory Ridge,Hypocone,Cusp5 ,Carabelli Trait,Parastyle ,Enamel Extension, Root Number,Peg/Reduced/Congenital Absence,Lingual Cusp Number ,Groove Pattern, Cusp Number ,Cusp-Number,Deflecting Wrinkle, Distal Trigonid Crest ,Protostylid , Cusp 7, Tome's Root'	Southeast Asians(Thailand, Philippines, Malaysia, Indonesia, and Prehistoric Taiwan)	Has has lower UI1 shoveling (26.8%–37.2%), lower UI1 double shoveling (9.6%–28.4%), and moderate UI1 winging (13.0%–29.2%). UM2 hypocone absence is 50%–75%, while UM1 cusp 5 (24.4%) and UM1 Carabelli trait (24.6%–41.9%) occur moderately. LM2 four cusps (25.8%–50%) and LM2 Y-groove pattern (25.4%–42.7%) are higher than in Sinodonts, while LM1 deflecting wrinkle (6.0%–10.6%) and LM1 cusp 7 (8.5%–22.2%) are moderate, with higher LM2 four cusps and lower UI1 shoveling being key **Sundadont traits.**
13	Turner CG et al[94]	'Winging, Shoveling ,Double Shoveling,Interruption Groove,Tuberculum Dentale,Mesial-Ridge,Distal Accessory Ridge,Hypocone,Cusp5 ,Carabelli Trait,Parastyle ,Enamel Extension, Root Number,Peg/Reduced/Congenital Absence,Lingual Cusp Number ,Groove Pattern, Cusp Number ,Cusp-Number,Deflecting Wrinkle, Distal Trigonid Crest ,Protostylid , Cusp 7, Tome's Root'	South Asians (India), Africa, and Europe	UI1 shoveling is low in Africa (7.3%) and very low in Europe (2.3%), with South Asians likely having similarly low frequencies. UM2 hypocone absence is very high in Africa (96.4%) and high in Europe (76.3%), with South Asians estimated between 75%–90%. UM1 cusp 5 occurs at a high frequency in Africa (62.5%) but is very low

				in Europe (11.8%), while LM1 cusp 7 is very high in Africa (49.3%) but very low in Europe (5.9%), with South Asians expected to have moderate levels. It highlight the unique dental characteristics of South Asian and Old World populations compared to Sinodont and Sundadont groups.
14	Rahmeh A et al[95]	Carabelli's Tubercle/Cusp, Cusp5(Metaconule),4-Cusped (Hypoconulid Absence),Cusp 6 (Tuberculum Sextum),Cusp 7	Southern Jordanians	Carabelli's-trait (42.1%) and cusp 5 on UM1 (64.4%) were more frequent. Hypoconulid absence (4-cusped LM1) was higher(4.1%), while cusp 6 (17.4%) and cusp 7 (18.7%) on LM1 showed intermediate frequencies. Compared to non-Middle Eastern,Western Eurasian populations, Southern Jordanians had more complex dental traits, particularly higher frequencies of Carabelli's trait and cusp 5, indicating distinct regional variation
15	Felemban NH et al[96]	Number of cusps (4-cusp, 5-cusp patterns),Occlusal-groove patterns ("Y" and "+" patterns)	Saudi Arabia	They exhibit the 5-cusp "Y" pattern in first molars (85%) and the 4-cusp "+" pattern in second molars (82%). The 1st molar groove patterns differed significantly from other global populations. The Second molar cusp and groove patterns were similar to East African and Iranian populations.
16	Kobayashi K et al[97]	'Shoveling,Double Shoveling,Tuberculum Dentale,Mesial Ridge,Distal Accessory Ridge,Lingual Cusp Variation,Odontomes,Hypocone	Hani Ethnic Group(China)	High frequencies of UI1 shoveling (55%) and UM2 hypocone reduction (84.1%) indicate some Sinodont

		Reduction,Cusp5 (Metaconule),Carabelli's Trait,Protostylid,Deflecting Wrinkle,Distal Trigonid Crest ,Cusp 6,Cusp 7,Y-Groove Pattern,Cusp Number'		influence.Lower frequencies of UI1 double shoveling (15.1%) and cusp 6 (7.9%) , cusp 7 3.41%align more with Sundadont populations. The Hani dental pattern closely resembles the Sundadont pattern (Southeast Asian populations) despite the Hani tribe's geographic location in a Sinodont region (Northeast Asia).
17	Tinoco et al[98]	Shoveling,Carabelli's Cusp ,Fifth Cusp (Cusp 5) ,Hypocone Absence,Sixth Cusp,Hypoconulid Absence	Brazilian	The most common trait was hypoconulid absence (83%), followed by hypocone absence (58.3%). Fifth cusp (24.8%), Carabelli's cusp (19.4%), and sixth cusp (15%) were found at moderate levels, while shoveling was low (14.3%), differing from Amerindian populations. Males had higher frequencies of Carabelli's cusp and the sixth cusp, while females showed more hypocone absence. These results suggest a mix of European and Sub-Saharan African ancestry, making the Brazilian dental pattern different from Amerindians and South Americans.
18	Coppa A et al[99]	'Hypocone Reduction,Cusp 5 (Metaconule)Presence, Carabelli's Trait,Parastyle(C2) Presence, Enamel Extensions, Molar Root Number,Congenital Absence, (Third-Molar),Anterior Fovea,Groove Pattern (Y-Groove),Cusp Number,Distal TrigonidCrest,Protostylid Presence, Cusp 7'	Neolithic Maltese Population	High hypocone presence (96.3% in UM1) and moderate presence in UM2 (56.1%) suggest a strong genetic link to Southern European and North African populations. Cusp 5 (Metaconule) was rare in UM1 (3.1%) but more frequent in UM3 (44.0%), aligning with populations from Carthage and Kabyle

				Berbers. Carabelli's trait was moderately present (16.7% in UM1) and very low in UM2 and UM3 (3.0% and 5.9%), indicating some similarity to Mediterranean and European populations. Y-groove patterns in LM2 (41.7%) and LM3 (48.5%) suggest shared ancestry with North African and Middle Eastern populations. Cusp 7 was rare (≤3.6%), differing from Sub-Saharan and East Asian populations where it is more common
19	Bano S et al[100]	Shoveling	Pakistani Punjabi	31.2% of individuals had shovel-shaped incisors.The **prevalence was lower** than in North American, South American, and North Asian populations, where this trait is highly common. Results align with previous studies in **India and Pakistan**, showing lower shoveling frequencies compared to Mongoloid populations.
20	Hassan S et al[101]	Cusp of Carabelli	Kashmiri	Cusp of Carabelli was present in 25% of individuals, lower than reported in European populations but higher than in Mongoloid groups.The findings suggest a mix of genetic influences in the Kashmiri population, showing similarities with South Asian and Middle Eastern populations.

MATERIALS AND METHODS

ETHICAL APPROVAL

Ethical approval for the study was taken from the institutional ethical review committee. Ethical clearance was acquired with clearance number 1632 (Annexure V)

SAMPLE:

The sample will be collected from the selected major ethnic groups i.e., Kachari, Mising, Bodo & Deori population of Lakhimpur and Dibrugarh, Assam.

- Dental full mouth impressions from the study population will be obtained. Prepared dental cast will be used for the study.
- The study will be conducted in the Department of Oral & Maxillofacial Pathology & Microbiology, KLE VKIDS, Belagavi.

Sample size estimation:

- Sample size at 95% confidential interval,
- Tolerable error of 20% & 10% attrition (1.1)

$$n = \frac{Z^2_{1-\alpha/2}\, pq}{(20\% \text{of } p)^2} \times 1.1$$

where, $Z_{1-\alpha/2} = 1.96$

p = 22.3 % (presence of shoveling)

q = 100-p

n = 368

- Among 368, using the Proportional allocation method are divided in each group 106,195,37,30 in Mising, Bodo, Kachari, Deori respectively.

- Again, Proportional allocation method has been used to select number of male & female for each group.

- In Mising 54 males & 52 females, Bodo 98 males &females, Kachari 19 males &18 females, Deori 15 males & females selected respectively.

Inclusion criteria:

- The study includes 368 individuals aged between 11-40 years

- People who have all of their teeth and gingiva in good condition up until the second molars.
- People who are belonging to any of the four ethnic groups.

- Individuals who are willing to give demographic data and to take dental impressions.

Exclusion criteria:

- Those who have received orthodontic treatment or who have experienced a substantial loss of tooth substance as a result of cavities, restoration, or attrition will not be allowed.

- Individuals not belonging to the four ethnic groups.

- Individuals not willing to participate.

DEMOGRAPHIC DETAILS

Demographic data were recorded (Annexure IV) along with informed consent form in three languages (Annexure I, II, III) for every individual included in the study for all the four group.

MATERIALS

Impression Compound	Mixing Spatula
Dental Stone	PMT set
Perforated Trays	Patient Gown
Rubber Bowls	Vernier Caliper
Arizona State University Dental Anthropology System (ASUDAS)	Magnifying Glass

METHODOLOGY

Details of the procedures to be conducted during the research:

The sample was collected from 1st of December 2023 to 10th February 2024.Informed consent was taken from the participating individuals total 404 of the four major ethnic groups Kachari, Mising, Bodo & Deori of Assam.

Ethnic Group	Male	Female	Total
Bodo	104	102	206
Mising	60	62	122
Deori	20	19	39
Kachari	21	16	37

According to the Proforma, people were asked for information such as their name, age, sex, address, prior dental history, and ethnicity. Using the proper perforated trays for the maxilla and mandible, oral examinations were performed and full mouth impressions with alginate were created for research participants. To prevent model distortion, disposable diagnostic tools and autoclaved perforated trays were also utilised. Imprints were quickly made using premium dental stone.

The cast was analysed for both metric and non-metric characteristics at the KLE VK Institute of Dental Sciences, Belagavi, in the Department of Oral & Maxillofacial Pathology. INSIZE digital Vernier calliper sensitive to 0.01mm was used to measure buccolingual and mesiodistal crown dimensions for dental metrics data in all permanent maxillary and mandibular crowns for central and lateral incisors, canines, first and second premolars, and first and second molars. With the calliper beaks positioned occlusally along the tooth's long axis, the largest distance between the contact points on the proximal surfaces was taken into account for MD measurements.

Measurements were made between locations on the proximal surfaces of teeth that were rotated or misaligned, where contact with neighbouring teeth would have typically taken place. The measurements were essentially the calliper's maximum actual access, which might not have been identical to the anatomical crest of curvature. The greatest distance between the lingual surface and the buccal/labial surface was determined via BL measurements. As previously mentioned, the calliper beaks were held at right angles to the MD dimension during the measurement. [61]

Interobserver variability between several observers may lead to more measurement variability than that of a single observer, claim Mincer et al. However, Mincer et al. reported that this method was deliberate.[19] who intended some degree of inter-observer variability by specialists. Additionally, they proposed that these realities are necessary in forensic casework because examiners frequently rely on published standards and might not be calibrated to do the tests using created equations. They are anthropologists, oral anatomists, and dentists with training who use the definitions found in the literature. Since inter-observer variability has been used in forensic dental age estimation studies in the past, it may be regarded as a practical strategy.[104]

Non-Metric Trait: Using the Arizona State University Dental Anthropology System (ASUDAS), six dental morphological characteristics were rated as follows:

Shoveling: Teeth to be examined are Upper Central and Lateral Incisors & the traits are evident on the lingual surface as mesial and distal marginal ridges.

Carabelli's Trait: Teeth to be examined are Upper First Molar & the traits are lingual surface of the upper molars' mesiolingual cusp.

Cusp 4/ Hypocone Absence: Teeth to be examined are Upper Second Molar & the traits are absence/ severely reduced distolingual cusp.

Cusp 5/Hypoconulid Absence: Teeth to be examined are Lower First and Second Molar & the traits are absence/ severely reduced distal cusp.

Cusp 6/Entoconulid: Teeth to be examined are Mandibular 1st molar & the traits are absence or presence of cusp between distolingual cusp and distobuccal cusp.

Cusp 7/ Metaconulid: Teeth to be examined are Mandibular 1st molar & the traits are absence or presence of cusp between distolingual cusp and mesiolingual cusp.

All the measurements were entered in Microsoft Excel as Metric data maxilla and Metric data mandible. The score of all the non-metric traits were also entered in Microsoft Excel as Non metric data.

Measurement for inter and intraobserver agreement:

Two observers measured individually 50 maxillary and 50 mandibular cast (28 MD and BL dimensions for every cast) for testing interobserver agreement, while one observer measured the same casts at different time point for evaluating intraobserver agreement. Observers were blinded to the subjects' demographic data (including sex) to prevent bias. Measurements were taken at two different times by the same observer to record intraobserver measurements and were measured by another observer for recording interobserver measurements.

Statistical Analysis:

Independent Samples t-test: Used on the reference sample to assess univariate sexual dimorphism (i.e., significant differences in tooth dimensions between males and females).

Stepwise Logistic Regression Analysis (LRA): Applied to the reference illustration to develop logistic regression formulae for sex prediction. The stepwise LRA approach selected the most significant tooth variables for sex determination.

For Non metric traits: The data of NMDT (Non-Metric Dental Traits) for statistical analysis, the observation was exported to SPSS 26.0 software after being entered into an Excel sheet.

Frequency & Percent % Distribution: The occurrence of various dental traits (e.g., winging, shovelling, etc.) was calculated as frequency the number of occurrences of each trait. Percent distribution is done by the proportion (%) of individuals showing each trait relative to the total sample size.

Two-proportion z-test to compare the frequency of dental traits between ancestry groups. The p-value threshold was set at <0.05

Kappa Statistics was applied to compare the repeat measurements for inter and intraobserver variation/agreement.

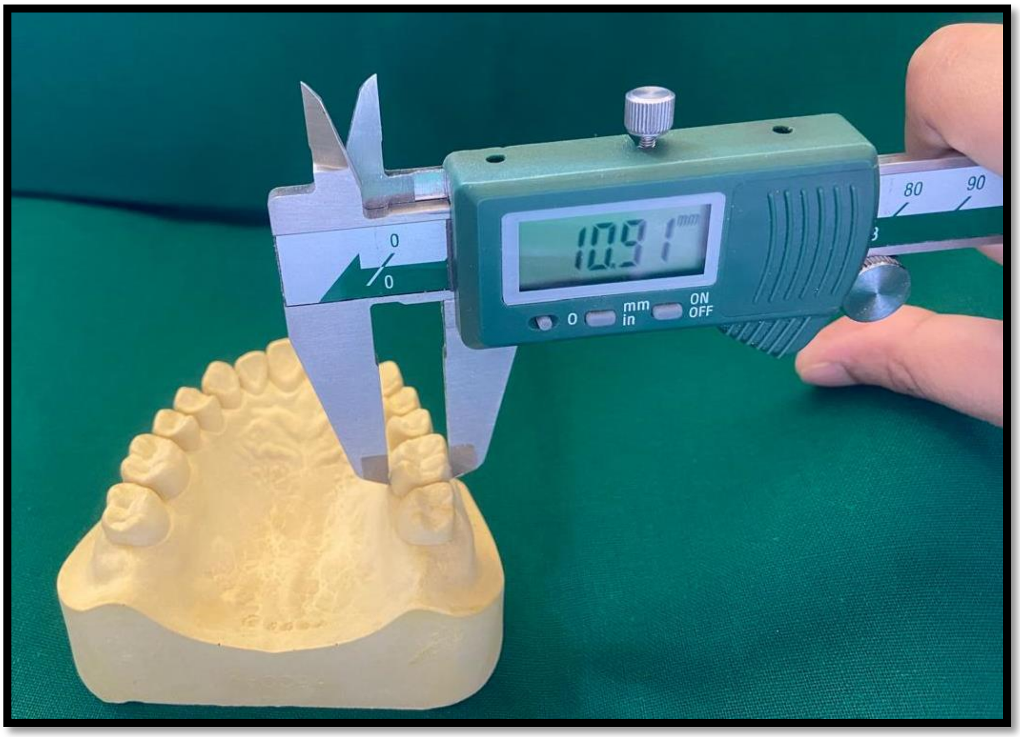
For the specified dental trait, a p-value < 0.05 denotes a statistically significant difference between the two ancestry groups, while a p-value > 0.05 denotes no significant difference in the trait's occurrence between the groups.

Picture 1: Dental Check-up camp organised in Assam

Picture 2: Investigator taking a maxillary impression using perforated tray and alginate.

Picture 3: INSIZE digital vernier caliper used in the study.

Picture 4: Measurement of Mesiodistsal diameter of left maxillary first molar



Picture 5: Measurement of Buccolingual diameter of left maxillary first molar

Picture 6: Analyzing cast according to Arizona State University Dental Anthropology System (ASUDAS) for Non-metric traits.

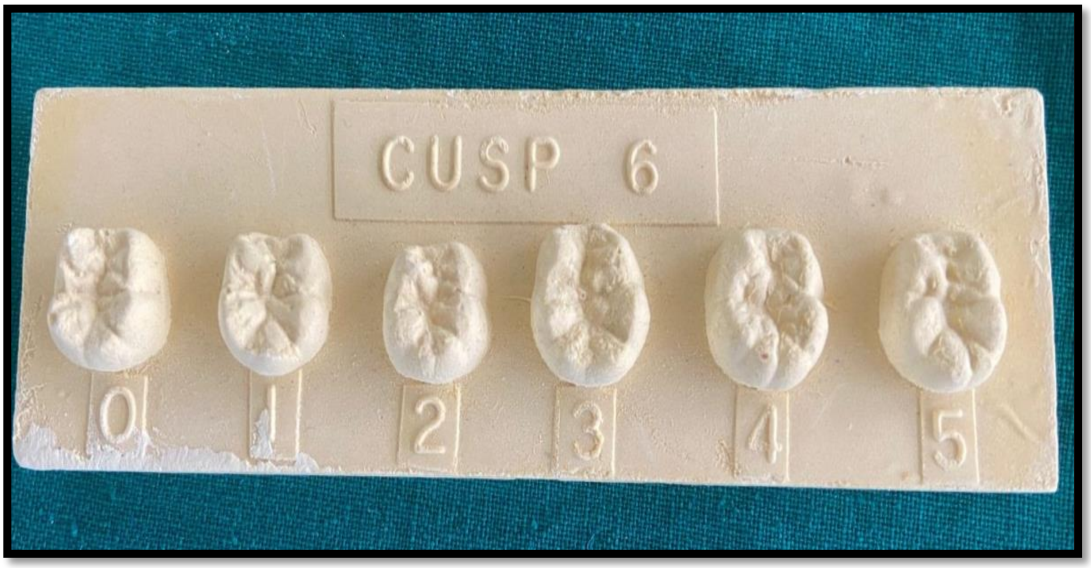
Picture 7: Shoveling: Teeth to be examined are Upper Central Incisors.

Picture 8: Shoveling: Teeth to be examined are Upper Lateral Incisors

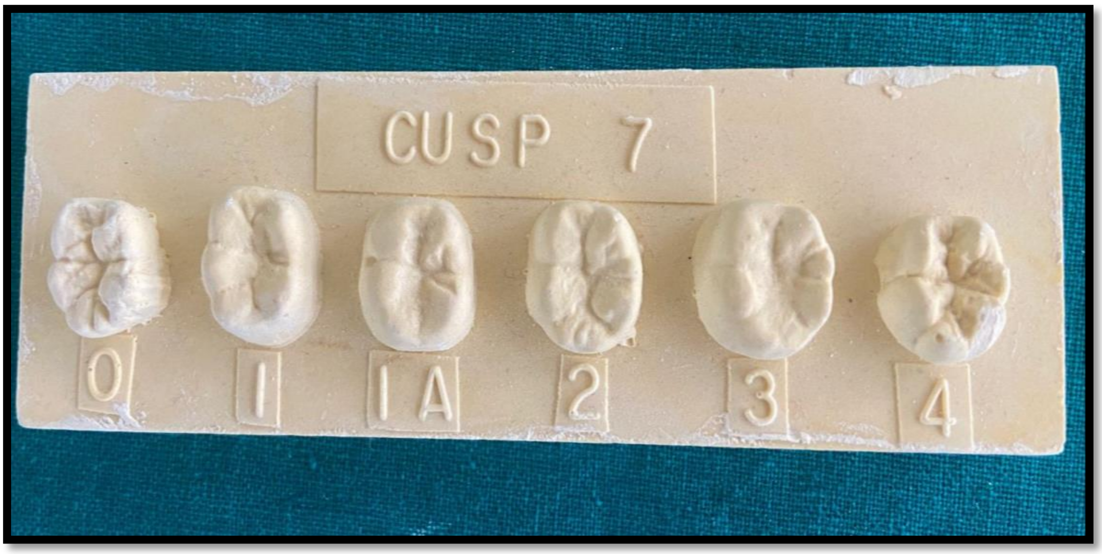
Picture 9: Carabelli's Trait: Teeth to be examined are Upper First Molar

Picture 10: Cusp 4/ Hypocone Absence: Teeth to be examined are Upper Second Molar.

Picture 11: Cusp 5/Hypoconulid Absence: Teeth to be examined are Lower First and Second Molar.



Picture 12: Cusp 6/Entoconulid: Teeth to be examined are Mandibular 1st molar



Picture 13: Cusp 7/ Metaconulid: Teeth to be examined are Mandibular 1st molar

RESULTS

404 maxilla cast & 404 mandible cast used with a total of 808 casts of the four major ethnic groups Kachari, Mising, Bodo & Deori of Assam.The total Bodo population is 206, comprising 104 males and 102 females. The Mising community consists of 122 individuals, with 60 males and 62 females. The Deori population totals 39, including 20 males and 19 females. Meanwhile, the Kachari population stands at 37, with 21 males and 16 females.

Metric Traits: The data was recorded for buccolingual and mesiodistal crown dimensions for all of the permanent mandibular and maxillary crowns, such as the canines, central and lateral incisors, first and second premolars, and first and second molars.

Measurement Undertaken: MD (mesio-distal) and BL (bucco-lingual) dimensions of

- Maxilla teeth: 14 teeth with 2 measurements of dimensions are 28
- Mandible teeth: 14 teeth with 2 measurements of dimensions are 28
- Both: 56 dimensions
- Total Measurements: 56 dimensions x 404 casts = 22624 measurements were taken

Nonmetric Traits: The Arizona State University Dental Anthropology System (ASUDAS) evaluated six dental morphological characteristics as follows:-

- Presence of Shoveling in upper central incisor
- Presence Shoveling in upper lateral incisor
- Presence of cusp of carabelli in the mesiopalatal cusp of maxillary first molar

- Absence of cusp 4 in maxillary 2nd molar
- Absence of cusp 5 (36,46) in maxillary 1st molar
- Absence of cusp 5 (37,47) in maxillary 2nd molar
- Presence of cusp 6 in mandibular 1st molar
- Presence of cusp 7 mandibular 1st

Metric Traits

Parameters considered: Buccolingual dimension & Mesiodistal dimension

Compared with: Male and female and ethnic groups: Bodo, Deori, Kachari, Mising

Table 3: Comparison of MD and BL dimensions of Maxillary teeth in males & females using the independent-t test.

Dimensions	Male			Female			t-value	p-value
	n	Mean	SD	n	Mean	SD		
11MD	206	8.51	0.62	198	8.39	0.69	1.7915	0.0740
11BL	206	7.22	0.70	198	7.04	0.66	2.5895	0.0100*
12MD	206	6.78	1.01	198	6.69	0.92	0.9386	0.3485
12BL	206	6.26	0.99	198	6.20	0.89	0.7131	0.4762
13MD	206	7.75	0.66	198	7.49	0.62	4.0523	0.0001*
13BL	206	7.82	0.75	198	7.61	0.72	2.8185	0.0051*
14MD	206	7.08	0.85	198	7.08	0.59	-0.0020	0.9984
14BL	206	9.37	1.26	198	9.26	0.65	1.1123	0.2667
15MD	206	6.62	0.62	198	6.64	0.89	-0.3091	0.7574
15BL	206	9.27	0.71	198	9.21	0.66	0.7850	0.4329
16MD	206	10.69	4.74	198	10.16	1.12	1.5192	0.1295
16BL	206	11.20	0.73	198	10.94	0.96	3.1284	0.0019*
17MD	206	9.61	1.12	198	9.41	1.00	1.9024	0.0578
17BL	206	10.90	1.08	198	10.62	1.25	2.3724	0.0181*
21MD	206	8.56	0.74	198	8.47	0.80	1.2136	0.2256
21BL	206	7.26	0.80	198	7.11	0.87	1.8207	0.0694
22MD	206	6.92	0.81	198	6.85	0.82	0.8960	0.3708
22BL	206	6.34	0.92	198	6.26	0.84	0.9921	0.3217
23MD	206	7.84	0.54	198	7.60	0.55	4.3744	0.0001*
23BL	206	7.88	0.76	198	7.68	0.76	2.6640	0.0080*
24MD	206	7.18	0.56	198	7.19	0.73	-0.2008	0.8410
24BL	206	9.33	0.65	198	9.12	0.83	2.8567	0.0045*
25MD	206	6.77	0.68	198	6.79	0.88	-0.1943	0.8461
25BL	206	9.35	0.71	198	9.17	0.80	2.4347	0.0153*
26MD	206	10.35	0.71	198	10.09	0.86	3.3585	0.0009*
26BL	206	11.22	0.80	198	11.10	0.75	1.5785	0.1152
27MD	206	9.72	0.84	198	9.66	0.84	0.6880	0.4918
27BL	206	11.07	0.91	198	10.93	0.80	1.6789	0.0939

*$p<0.05$= Statistically Significant

Inference: Out of total number of 5656 maxillary teeth included in the study, we found most of the dimensions were bigger in males as compared to females. On applying the independent sample's t-test, a statistically significant difference (p= <0.05) in maxillary teeth dimensions between male and females was observed with i.e. 11BL, 13MD, 13MD, 13BL, 16BL, 17BL, 23MD, 23BL, 24BL, 25BL & 26MD with all these dimensions being larger in males as compared to the female population. The dimensions for 15MD,24MD,25MD were larger in females showing reverse dimorphism though did not show statistical significance (Table3).

Table 4: Comparison of MD and BL dimensions of Mandibular teeth in males & females using the independent -t test.

Dimensions	Male			Female			t-value	p-value
	n	Mean	SD	n	Mean	SD		
31MD	206	5.61	0.80	198	5.50	0.84	1.2950	0.1961
31BL	206	6.17	0.76	198	6.07	0.85	1.2158	0.2248
32MD	206	6.07	0.84	198	6.02	0.90	0.5164	0.6058
32BL	206	6.22	0.87	198	6.17	0.80	0.5882	0.5567
33MD	206	6.89	0.68	198	6.73	0.52	2.6509	0.0083
33BL	206	7.05	0.86	198	7.02	0.70	0.3174	0.7511
34MD	206	7.16	0.54	198	7.09	0.50	1.3334	0.1832
34BL	206	7.95	0.68	198	7.81	0.60	2.2481	0.0251*
35MD	206	7.04	0.78	198	7.04	0.77	-0.0053	0.9958
35BL	206	8.40	0.75	198	8.35	0.71	0.7858	0.4325
36MD	206	10.96	1.18	198	10.79	1.00	1.5495	0.1220
36BL	206	10.77	0.87	198	10.66	0.66	1.3826	0.1676
37MD	206	9.66	1.04	198	9.63	0.95	0.3069	0.7591
37BL	206	10.27	0.68	198	10.03	1.00	2.9026	0.0039*
41MD	206	5.63	0.77	198	5.44	0.79	2.4571	0.0144*
41BL	206	6.16	0.81	198	6.04	1.11	1.2671	0.2058
42MD	206	6.01	0.68	198	5.97	0.50	0.6820	0.4956
42BL	206	6.29	0.90	198	6.20	0.91	1.0083	0.3139
43MD	206	6.98	0.48	198	6.74	0.54	4.7769	0.0001*
43BL	206	7.17	0.73	198	7.14	0.68	0.5540	0.5799
44MD	206	7.20	0.54	198	7.09	0.56	2.0868	0.0375*
44BL	206	8.03	0.73	198	7.87	0.57	2.5919	0.0099*
45MD	206	7.03	0.76	198	7.05	0.82	-0.1873	0.8515
45BL	206	8.43	0.67	198	8.39	0.74	0.5809	0.5616
46MD	206	11.14	0.72	198	11.00	0.79	1.8631	0.0632
46BL	206	10.80	0.71	198	10.63	0.83	2.1547	0.0318*
47MD	206	10.08	0.99	198	10.03	0.76	0.5587	0.5767
47BL	206	10.20	0.68	198	10.18	0.70	0.3392	0.7346

*p<0.05= Statistically Significant

Inference: Out of total number of 5656 mandibular teeth included in the study, we found most of the dimensions were more in male as compared to females. On applying the independent sample's t-test. a statistically significant difference in the mandibular teeth dimensions between male and females was observed with 34BL, 37BL, 41MD, 43MD, 44MD,44BL & 46 BL with all these dimensions being larger in males as compared to the female population ($p < 0.05$). The dimensions for 35MD,45MD dimensions were larger in females showing reverse dimorphism but did not statistical significance (Table 4).

Table 5: Comparison of MD and BL dimensions of both maxillary and mandibular teeth among males/females using independent -t test.

Dimension	Male		Female		t-value	p value
	Mean	SD	Mean	SD		
1131MD	7.05	1.65	6.94	1.67	-0.955	0.34
1131BL	6.68	0.96	6.55	0.97	-2.054	0.04*
1232MD	6.41	1	6.33	1.07	-1.006	0.315
1232BL	6.25	0.93	6.16	0.96	-1.303	0.193
1333MD	7.32	0.8	7.12	0.69	-3.995	0.001*
1333BL	7.44	0.9	7.32	0.77	-1.964	0.05*
1434MD	7.12	0.72	7.09	0.55	-0.775	0.439
1434BL	8.66	1.24	8.54	0.96	-1.638	0.102
1535MD	6.83	0.74	6.84	0.86	0.176	0.861
1535BL	8.84	0.85	8.78	0.81	-0.992	0.322
1636MD	10.83	3.46	10.48	1.11	-1.905	0.057
1636BL	11.01	0.72	10.8	0.85	-3.891	0.001*
1737MD	9.85	4.58	9.53	0.99	-1.377	0.169
1737BL	10.57	0.85	10.37	0.99	-2.976	0.003*
2141MD	7.1	1.65	6.96	1.71	-1.199	0.231
2141BL	6.72	0.98	6.58	1.13	-1.843	0.066
2242MD	6.47	0.88	6.42	0.81	-0.894	0.371
2242BL	6.32	0.91	6.39	3.13	0.408	0.683
2343MD	7.42	0.67	7.17	0.7	-5.012	0.001*
2343BL	7.53	0.83	7.41	0.78	-2.141	0.033*
2444MD	7.19	0.55	7.32	3.62	0.701	0.483
2444BL	8.87	3.79	8.5	0.96	-1.901	0.058
2545MD	6.91	0.73	6.92	0.86	0.267	0.79
2545BL	8.89	0.84	8.78	0.87	-1.879	0.061
2646MD	11	5	10.54	1.04	-1.789	0.074
2646BL	11.01	0.81	10.87	0.83	-2.386	0.017*
2747MD	9.93	0.82	9.85	0.83	-1.349	0.178
2747BL	10.64	0.91	10.81	5.12	0.669	0.504

*p<0.05= Statistically Significant

Inference: Out of total of 11312 maxillary and mandibular teeth included in the study, we found most of the combined dimensions were larger in male as compared to females. The dimension combination of 1535MD, 2442BL,2444MD, 2545MD,2747BL were larger in females showing reverse dimorphism ($p>0.05$ NS). A statistically significant difference seen between male and females were observed with combined maxillary and mandibular parameters 1131BL,1333MD, 1333BL, 1636BL,1737BL,2342MD,2343BL & 2646BL by the independent sample's t-test. (Table 5).

Table 6: Stepwise (LRA)logistic regression analyses of teeth in both Maxilla and Mandible, Maxillary Teeth and Mandibular Teeth.

Tooth variable	B	S.E.	Wald	df	p-value	Exp(B)
Maxillary Teeth						
13MD	-0.4110	0.1930	4.5310	1.0	0.0330	0.6630
15BL	0.3760	0.2090	3.2280	1.0	0.0720	1.4570
23MD	-0.5590	0.2310	5.8380	1.0	0.0160	0.5720
24MD	0.3470	0.1800	3.7030	1.0	0.0540	1.4150
25BL	-0.3830	0.1860	4.2520	1.0	0.0390	0.6820
26MD	-0.3160	0.1470	4.6130	1.0	0.0320	0.7290
Constant	8.2170	2.1460	14.6670	1.0	0.0001	0.0000
Mandibular Teeth						
37BL	-0.3970	0.1580	6.2990	1.0	0.0120	0.6730
41MD	-0.2770	0.1630	2.8900	1.0	0.0890	0.7580
42MD	0.3770	0.2250	2.8260	1.0	0.0930	1.4590
43MD	-1.0200	0.2370	18.5320	1.0	0.0001	0.3600
47BL	0.4080	0.1880	4.7000	1.0	0.0300	1.5030
Constant	6.1090	1.9850	9.4670	1.0	0.0020	0.0000
Teeth of both jaws						
11MD	0.1340	0.0750	3.1860	1.0	0.0740	1.1430
13MD	-0.2480	0.1390	3.1720	1.0	0.0750	0.7810
25BL	0.2260	0.1280	3.1290	1.0	0.0770	1.2530
27BL	-0.1970	0.0980	4.0220	1.0	0.0450	0.8210
33MD	-0.6060	0.1660	13.3100	1.0	0.0001	0.5460
34BL	-0.2480	0.1240	3.9920	1.0	0.0460	0.7810
46MD	-0.2670	0.0960	7.7160	1.0	0.0050	0.7650
47BL	0.2930	0.1230	5.6570	1.0	0.0170	1.3410
Constant	7.1730	1.4580	24.2030	1.0	0.0001	0.0000

Inference:

For teeth in the maxilla out of 28 teeth dimensions– following dimensions i.e. 13MD,15MD,23MD,24MD,25BL and 26MD entered into stepwise logistic regression analyses. The stepwise logistic regression formula being: 8.210- (0.4110 x13MD) +(0.3760 x15BL)- (0.5590 x 23MD) +(0.3470x24MD) -(0.3830x25BL) -(0.3160x26MD).

For teeth in the mandible out of the 28 teeth dimensions evaluated, following dimensions i.e. 37BL,41MD,42MD,43MD and 47BL entered into stepwise logistic regression analyses. The stepwise logistic regression formula being: 6.1090- (0.3970 x 37BL) -(0.2770 x41MD)- (0.3770 x 42MD) -(1.0200 x 43 MD) + (0.4080 x 47BL).

For both maxilla and mandible, out of the 56 dimensions taken into consideration, the following dimensions i.e 11MD,13MD,25BL,27BL,33MD,34BL, 46MD and 47BL entered into stepwise logistic regression analyses. The stepwise logistic regression formula being: 7.1730 + (0.1340x11MD) -(0.2480 x13MD) + (0.2260 x 25BL) -(0.1970x 27BL) -(0.6060x 33MD) -(0.2480x 34BL) -(0.2670x46MD) +(0.2930x47BL)

Table 7: Sex Classification Accuracy of the logistic regression analyses (LRA).

Jaws	Observed Gender	Predicted			Percentage Correct
		Male	Female	Total	
Maxilla	Male	133	73	206	64.60
	Female	75	123	198	62.10
	Overall Percentage	208	196	404	63.40
Mandible	Male	132	74	206	64.10
	Female	83	115	198	58.10
	Overall Percentage	215	189	404	61.10
Both jaws	Male	260	152	412	63.10
	Female	157	239	396	60.40
	Overall Percentage	417	391	808	61.80

Inference: The accuracy for the LRA for teeth in maxillary jaw when used for sex identification was 63.40% and accuracy of mandibular was 61.10%. The accuracy when using both the jaws for sex identification was 61.80%.

Table8: Comparison of MD and BL dimensions of Maxillary teeth among the various ethnic groups using the one-way ANOVA test.

Dimensions	Bodo		Deori		Kachari		Mising		F-value	p-value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
11MD	8.47	0.67	8.34	0.52	8.58	0.85	8.42	0.60	1.0056	0.3902
11BL	7.14	0.68	7.24	0.72	7.40	0.75	7.01	0.66	3.4268	0.0172*
12MD	6.70	1.05	6.68	0.57	6.86	0.70	6.79	0.98	0.4672	0.7053
12BL	6.24	0.99	6.23	0.62	6.44	0.89	6.15	0.94	0.9177	0.4323
13MD	7.62	0.64	7.53	0.82	7.79	0.52	7.60	0.65	1.0903	0.3530
13BL	7.74	0.74	7.72	0.71	7.92	0.77	7.61	0.72	1.9204	0.1257
14MD	7.07	0.50	6.96	1.24	7.18	0.64	7.11	0.86	0.6186	0.6033
14BL	9.37	0.84	9.13	1.59	9.45	0.72	9.23	1.10	1.1361	0.3342
15MD	6.64	0.81	6.71	0.50	6.70	0.77	6.57	0.75	0.4979	0.6840
15BL	9.29	0.63	9.32	0.66	9.25	1.09	9.12	0.60	1.8317	0.1408
16MD	10.60	4.81	10.28	0.64	10.25	0.76	10.23	0.85	0.3578	0.7835
16BL	11.11	0.71	11.21	0.64	10.79	1.83	11.05	0.67	1.8861	0.1313
17MD	9.54	1.16	9.32	0.85	9.45	0.90	9.54	1.01	0.5584	0.6428
17BL	10.79	0.91	10.81	0.92	10.87	0.93	10.67	1.63	0.3955	0.7563
21MD	8.48	0.83	8.52	0.82	8.66	0.65	8.53	0.68	0.6314	0.5951
21BL	7.21	0.85	7.20	0.98	7.32	0.68	7.11	0.82	0.6797	0.5649
22MD	6.82	0.86	6.90	0.80	7.05	0.63	6.94	0.79	1.0630	0.3646
22BL	6.39	0.95	6.19	0.78	6.31	0.76	6.17	0.82	1.8359	0.1400
23MD	7.74	0.51	7.85	0.61	7.76	0.66	7.65	0.58	1.4370	0.2315
23BL	7.79	0.78	7.78	0.84	7.95	0.64	7.71	0.75	0.9562	0.4134
24MD	7.21	0.72	7.05	0.52	7.14	0.58	7.20	0.57	0.7247	0.5377
24BL	9.30	0.74	9.08	0.78	9.32	0.73	9.13	0.77	2.0469	0.1068
25MD	6.79	0.80	6.72	0.68	6.83	0.69	6.78	0.82	0.1458	0.9323
25BL	9.30	0.75	9.27	0.67	9.34	0.79	9.17	0.79	0.8323	0.4767
26MD	10.23	0.78	10.25	0.84	10.32	0.85	10.19	0.79	0.2562	0.8569
26BL	11.16	0.76	11.29	0.58	11.30	0.76	11.08	0.84	1.1235	0.3393
27MD	9.70	0.86	9.69	0.86	9.80	0.87	9.65	0.80	0.3391	0.7971
27BL	11.01	0.81	10.81	0.83	11.14	0.94	11.01	0.91	0.9464	0.4181

*p<0.05

Inference: Results show the maxillary teeth parameters are almost uniform for all ethnic groups except for 11BL (p - 0.0172) which is statistically significantly different among the groups**.**

Table 9: Comparison of MD and BL dimensions of mandibular teeth among the various ethnic groups using the one-way ANOVA test.

Dimensions	Bodo		Deori		Kachari		Mising		F-value	p-value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
31MD	5.62	0.92	5.68	1.04	5.42	0.41	5.44	0.64	1.7804	0.1503
31BL	6.13	0.80	6.35	0.79	5.93	0.83	5.99	0.71	1.7431	0.1576
32MD	6.10	0.97	6.14	0.91	5.82	0.49	6.01	0.78	1.3667	0.2525
32BL	6.22	0.82	6.27	0.58	5.81	1.28	6.16	0.66	2.1745	0.0905
33MD	6.84	0.71	6.81	0.48	6.83	0.45	6.75	0.51	0.6995	0.5528
33BL	6.99	0.87	7.24	0.61	7.00	0.75	6.95	0.65	1.0873	0.3543
34MD	7.14	0.51	7.22	0.48	7.20	0.50	7.06	0.58	1.8170	0.1434
34BL	7.89	0.71	7.90	0.57	8.01	0.68	7.81	0.56	0.8708	0.4562
35MD	7.11	0.85	7.01	0.52	7.18	0.54	6.95	0.75	1.8035	0.1459
35BL	8.33	0.83	8.58	0.55	8.63	0.70	8.33	0.60	2.6830	0.0464
36MD	10.85	1.07	10.92	1.12	11.20	0.81	10.83	1.26	1.0409	0.3743
36BL	10.66	0.88	10.97	0.52	10.88	0.92	10.69	0.60	2.2707	0.0798
37MD	9.67	1.05	9.51	1.14	9.62	1.10	9.66	0.88	0.3416	0.7953
37BL	10.10	0.91	10.35	0.94	10.36	0.78	10.11	0.81	1.8723	0.1337
41MD	5.56	0.76	5.64	0.85	5.44	0.38	5.47	0.92	0.6222	0.6010
41BL	6.08	0.94	6.23	0.70	6.12	1.07	6.00	1.04	0.2882	0.8339
42MD	6.04	0.54	5.96	0.46	5.79	1.11	5.92	0.49	1.4348	0.2321
42BL	6.29	0.88	6.36	0.81	5.99	1.31	6.08	0.77	1.4936	0.2158
43MD	6.89	0.53	6.83	0.60	6.82	0.44	6.83	0.54	0.6156	0.6052
43BL	7.17	0.75	7.22	0.64	6.98	0.81	7.06	0.60	0.6818	0.5636
44MD	7.10	0.54	7.21	0.42	7.30	0.48	7.10	0.48	1.8040	0.1458
44BL	7.97	0.76	8.07	0.47	8.09	0.64	7.84	0.56	1.9948	0.1142
45MD	7.02	0.75	7.06	0.52	7.06	0.56	7.01	0.85	0.2344	0.8724
45BL	8.43	0.76	8.65	0.61	8.63	0.62	8.26	0.65	5.2462	0.0015*
46MD	11.07	0.79	11.14	0.92	11.31	0.66	11.05	0.60	0.9323	0.4250
46BL	10.68	0.74	10.84	1.14	10.95	0.84	10.65	0.66	2.0652	0.1043
47MD	10.03	1.02	10.19	0.76	10.07	0.82	10.00	0.71	0.4693	0.7039
47BL	10.19	0.68	10.38	0.76	10.30	0.72	10.10	0.70	1.9607	0.1193

*p<0.05

Inference: Results show the mandibular teeth parameters are almost uniform for all ethnic groups except for 45BL (p - 0.0015) which is statistically significantly different among the groups.

Table10: Comparison of MD and BL dimensions of both jaws among the various ethnic groups using the one-way ANOVA test.

Dimension	Bodo		Deori		Kachari		Mising		F-value	p value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
1131MD	7.04	1.67	7.02	1.57	7	1.73	6.92	1.67	0.268	0.849
1131BL	6.62	0.96	6.8	0.88	6.68	1.07	6.53	0.97	1.728	0.16
1232MD	6.37	1.15	6.41	0.81	6.28	1.07	6.37	0.89	0.213	0.887
1232BL	6.21	1.01	6.26	0.6	6.16	1.14	6.2	0.85	0.145	0.933
1333MD	7.24	0.78	7.18	0.76	7.32	0.68	7.18	0.73	0.868	0.457
1333BL	7.38	0.89	7.48	0.7	7.5	0.9	7.31	0.76	1.425	0.234
1434MD	7.11	0.51	7.09	0.95	7.2	0.57	7.08	0.73	0.739	0.529
1434BL	8.64	1.07	8.52	1.34	8.73	1.01	8.53	1.13	0.941	0.42
1535MD	6.88	0.86	6.85	0.53	6.91	0.71	6.74	0.77	1.703	0.165
1535BL	8.82	0.88	8.94	0.71	8.93	0.97	8.72	0.72	2.112	0.097
1636MD	10.73	3.49	10.6	0.97	10.71	0.9	10.53	1.1	0.305	0.822
1636BL	10.91	0.71	11.06	0.66	10.84	1.44	10.87	0.66	1.343	0.259
1737MD	9.83	4.58	9.42	1.01	9.52	0.99	9.6	1.05	0.519	0.669
1737BL	10.45	0.97	10.59	0.96	10.62	0.88	10.43	0.84	1.345	0.259
2141MD	7.03	1.66	7.08	1.68	7.07	1.7	7.01	1.72	0.044	0.988
2141BL	6.65	1.06	6.72	0.98	6.73	1.05	6.6	1.09	0.424	0.736
2242MD	6.44	0.82	6.43	0.81	6.46	1.08	6.44	0.83	0.014	0.998
2242BL	6.36	0.92	6.28	0.8	6.17	1.05	6.42	3.92	0.26	0.854
2343MD	7.32	0.67	7.34	0.8	7.31	0.72	7.24	0.7	0.838	0.473
2343BL	7.49	0.83	7.5	0.8	7.5	0.86	7.42	0.75	0.488	0.691
2444MD	7.16	0.66	7.13	0.48	7.24	0.56	7.46	4.57	0.741	0.528
2444BL	8.82	3.8	8.58	0.83	8.71	0.92	8.49	0.93	0.759	0.517
2545MD	6.91	0.8	6.89	0.63	6.99	0.76	6.9	0.86	0.257	0.856
2545BL	8.86	0.88	8.96	0.71	8.99	0.79	8.71	0.86	3.344	0.019*
2646MD	10.88	5.01	10.62	1.4	10.79	0.9	10.62	0.83	0.309	0.819
2646BL	10.93	0.79	11.07	0.93	11.14	0.83	10.86	0.81	2.89	0.035*
2747MD	9.89	0.84	9.95	0.85	9.97	0.88	9.84	0.78	0.599	0.615
2747BL	10.6	0.86	10.6	0.82	10.73	0.93	10.98	6.5	0.578	0.63

*p<0.05

Inference: Results show the maxilla and mandible parameters combined are almost uniform for all ethnic groups except for 2545BL (p - 0.019, S) and 2646BL (p-0.035, S) which is statistically significantly different among the groups.

Non metric traits

Table 11: Frequency and Percent Distribution of different non-metric traits according to Gender (Chi Square test)

Traits	Gender				Total	%	Chi-square	p-value
	Male	%	Female	%	n=404			
Shoveling U.C.I								
Absent	91	51.12	87	48.88	178	44.06	0.002	0.962
Present	115	50.88	111	40.27	226	55.94		
Shoveling U.L.I								
Absent	109	51.17	104	48.83	213	53.96	0.001	0.984
Present	95	51.08	91	48.92	186	46.04		
Cusp of Carabelli								
Absent	158	50.16	157	49.84	315	77.97	0.395	0.529
Present	48	53.93	41	46.07	89	22.03		
Cusp 4 absence								
Absent	109	49.77	110	50.23	219	54.21	0.284	0.594
Present	97	52.43	88	47.57	185	45.79		
Cusp 5(36,46)								
Absent	45	47.87	49	52.13	94	23.27	0.476	0.49
Present	161	51.94	149	48.06	310	76.73		
CUSP 5(37,47)								
Absent	187	51.23	178	48.77	365	90.35	0.089	0.765
Present	19	48.72	20	51.28	39	9.65		
Cusp 6								
Absent	198	50.38	195	49.62	393	97.28	2.138	0.144
Present	8	72.73	3	27.27	11	2.72		
Cusp 7								
Absent	180	50.99	173	49.01	353	87.38	0	0.999
Present	26	50.98	25	49.02	51	12.62		

Inference:

- Shoveling in upper central incisor was present in 55.94% of the population. It was more commonly seen in teeth of males (50.88%) as compared to females (40.27%) (p-0.962, NS).

- Shoveling in upper lateral incisor was present in 46.04% of the population. It was more commonly in males (51.08%) as compared to females (48.92%) (p-0.984, NS).
- Presence of cusp of carabelli in various grades on the mesiopalatal cusp of upper first molar was seen in 22.03% of the population. It was more common in males (53.93%) as compared to females (46.07%) (p-0.529, NS)
- Absence of cusp 4 or hypocone absence in the upper/maxillary second molar was seen in 54.21% of the population. It was more common in females (50.23%) as compared to the males (49.77%) (p-0.594, NS).
- Absence of cusp 5 or hypoconulid absence in lower/mandibular first molar (36,46) was seen in 23.27% of the population. It was more common in females (52.13%) as compared to males (47.87%) (p-0.49, NS).
- Absence of cusp 5 or hypoconulid absence in lower/mandibular second molar (37,47) was seen in 90.35% of the population. It was more common in males (51.23%) as compared to females (48.77%) (p-0.765, NS).
- Presence of cusp 6 or entoconulid in the lower/ mandibular first molar (36,46) was seen in only 2.72% of the population. It was more common in males (72.73%) as compared to females (27.27%) (p-0.144, NS).
- Presence of cusp7 in the lower/ mandibular first molar (36,46) was seen in 12.62% of the population. It was more common in males (50.98%) as compared to females (49.02%) (p-0.999,NS).
- **None of the NM features showed any significant sexual dimorphism.**

Table 12: Frequency and Percent Distribution of different traits according to ancestry

Traits	Ancestry								Total	%	Chi-square	p-value
	Mising	%	Kachari	%	Bodo	%	Deori	%				
Shovelling U.C. I												
Absent	63	51.64	11	29.73	84	40.78	20	51.28	178	44.06	7.6530	0.0540*
Present	59	48.36	26	70.27	122	59.22	19	48.72	226	55.94		
Shovelling U.L. I												
Absent	76	62.30	14	37.84	100	48.54	28	71.79	218	53.96	14.7090	0.0020*
Present	46	37.70	23	62.16	106	51.46	11	28.21	186	46.04		
Cusp of Carabelli												
Absent	98	80.33	25	67.57	161	78.16	31	79.49	315	77.97	2.7820	0.4260
Present	24	19.67	12	32.43	45	21.84	8	20.51	89	22.03		
Cusp 4												
Absent	69	56.56	12	32.43	114	55.34	24	61.54	219	54.21	8.2900	0.0400*
Present	53	43.44	25	67.57	92	44.66	15	38.46	185	45.79		
Cusp 5(16,26)												
Absent	27	22.13	6	16.22	45	21.84	16	41.03	94	23.27	8.2410	0.0410*
Present	95	77.87	31	83.78	161	78.16	23	58.97	310	76.73		
CUSP 5(17,27)												
Absent	110	90.16	32	86.49	186	90.29	37	94.87	365	90.35	1.5530	0.6700
Present	12	9.84	5	13.51	20	9.71	2	5.13	39	9.65		
Cusp 6												
Absent	121	99.18	36	97.30	197	95.63	39	100.00	393	97.28	4.8680	0.1820
Present	1	0.82	1	2.70	9	4.37	0	0.00	11	2.72		
Cusp 7												
Absent	108	88.52	31	83.78	179	86.89	35	89.74	353	87.38	0.8210	0.8450
Present	14	11.48	6	16.22	27	13.11	4	10.26	51	12.62		
Total population	122	100.00	37	100.00	206	100.00	39	100.00	404	100.00		

*p<0.05

Description: analyses including 07 non-metric traits in total 4 ethnic intergroup from the state Assam were taken.

Inference:

- Shoveling in upper central incisor was more commonly seen in teeth of Kachari (70.27%), Bodo (59.22%), Mising (48.36%) and Deori (48.72) (p-0.0540, S).
- Shoveling in upper lateral incisor was more commonly seen in teeth of Kachari (62.16%), Bodo (51.46%), Mising (37.70%) and Deori (28.21) (p-0.0020, S).
- Presence of cusp of carabelli in various grades on the mesiopalatal cusp of upper first molar was more commonly seen in teeth of Kachari (32.43%), Bodo (21.84%), Deori (20.51) and Mising (19.67%) (p-0.4260, NS).
- Absence of cusp 4 or hypocone absence in the upper/maxillary second molar was more commonly seen in teeth of Deori (61.54), Bodo (55.34%), Mising (56.56%) and Kachari (32.43%) (p-0.0400, S).
- Absence of cusp 5 or hypoconulid absence in upper maxillary first molar (16,26) was more commonly seen in teeth of Kachari (16.22%), Bodo (21.84%), Mising (22.13%) and Deori (41.03) (p-0.0410, S).
- Absence of cusp 5 or hypoconulid absence in upper maxillary second molar (17,27) was more commonly seen in teeth of Kachari (86.49%), Bodo (90.29%), Mising (90.16%) and Deori (94.87) (p-0.6700, NS).
- Presence of cusp 6 or enteroconulid in the lower/ mandibular first molar (36,46) was more commonly seen in teeth of Kachari (2.70%), Bodo (4.37%), Mising (0.82%) and Deori (00) (p-0.1820, NS).

- Presence of cusp7 in the lower/ mandibular first molar (36,46) was more commonly seen in teeth of Kachari (16.22%), Bodo (13.11%), Mising (11.48%) and Deori (10.26) (p-0.8450, NS).
- In Mising group –

  Most prominent traits seen are absence of Cusp 5 (17,27) is 90.16% followed by absence of Cusp 4 is 56.56%, shovelling in upper central incisor is 48.36% and upper lateral incisor is 37.7%, absence of Cusp 5 (16,26) is 22.13%, Cusp of Carabelli is 19.67%, Cusp 7 - 11.48% and Cusp 6 which is 0.82% the least prominent trait
- In Kachari group –

  Most prominent traits seen are shovelling in both upper central incisor is 70.27% & upper lateral incisor is 62.16%, followed by absence of Cusp 5 (17,27) is 86.49%, absence of Cusp 4 is 32.43%, Cusp of Carabelli is 32.43% followed by absence of Cusp 5 (16,26) that is 16.22%, Cusp 7 is 16.22% and the least prominent trait Cusp 6 is 2.7%.
- In Bodo group -

Most prominent traits seen are absence of Cusp 5 (17,27) which is 90.29%, shovelling upper central incisor is 59.22%, shovelling upper lateral incisor is 51.46%, absence of Cusp 4 is 55.34%, absence of Cusp 5 (16,26) is 21.84%, Cusp of Carabelli is 21.84%, Cusp 7 is 13.11%, Cusp 6 is 4.37% which is highest among all groups but least prominent overall.

- In Deori group-

Most prominent traits seen are absence of Cusp 5 (17,27) is 94.87%, absence of Cusp 4 is 61.54%, shovelling upper central incisor is 48.72%, shovelling upper lateral incisor is 28.21%, absence of Cusp 5 (16,26) is 41.03%, Cusp of Carabelli is 20.51%, Cusp 7 is 10.26%and Cusp 6 which is completely absent 0%.

Figure 2: Total percent distribution of 07 traits in all the ethnic groups.

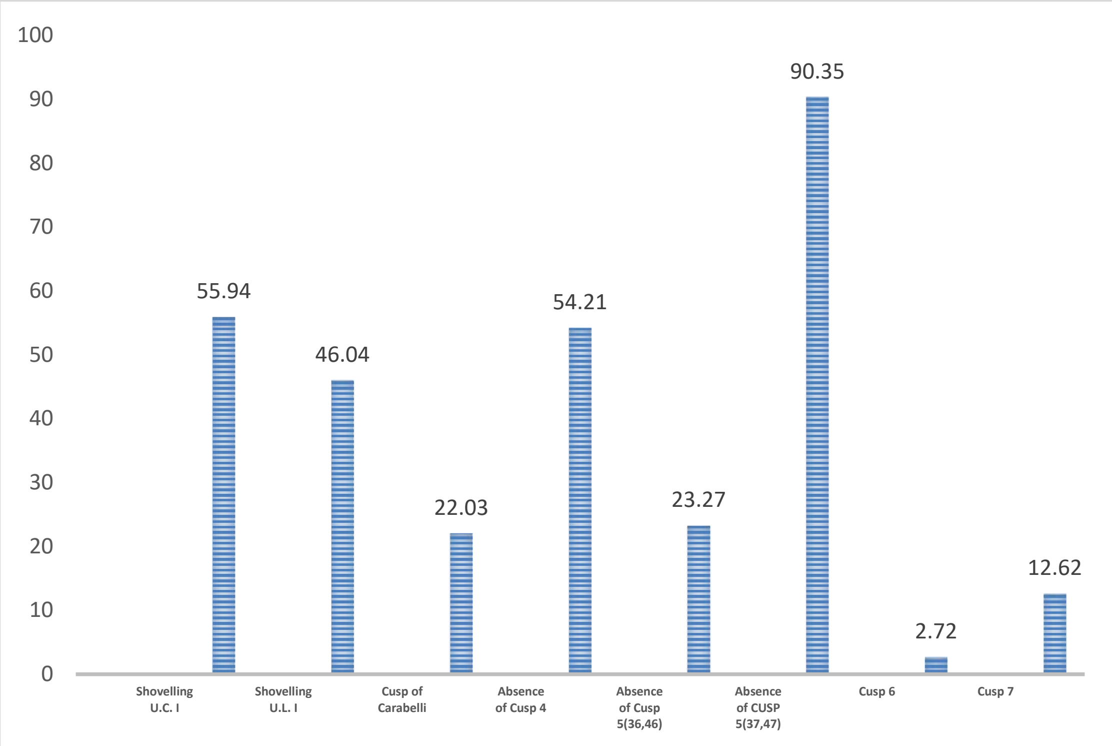


Figure 3: Percent Distribution of different traits according to Gender

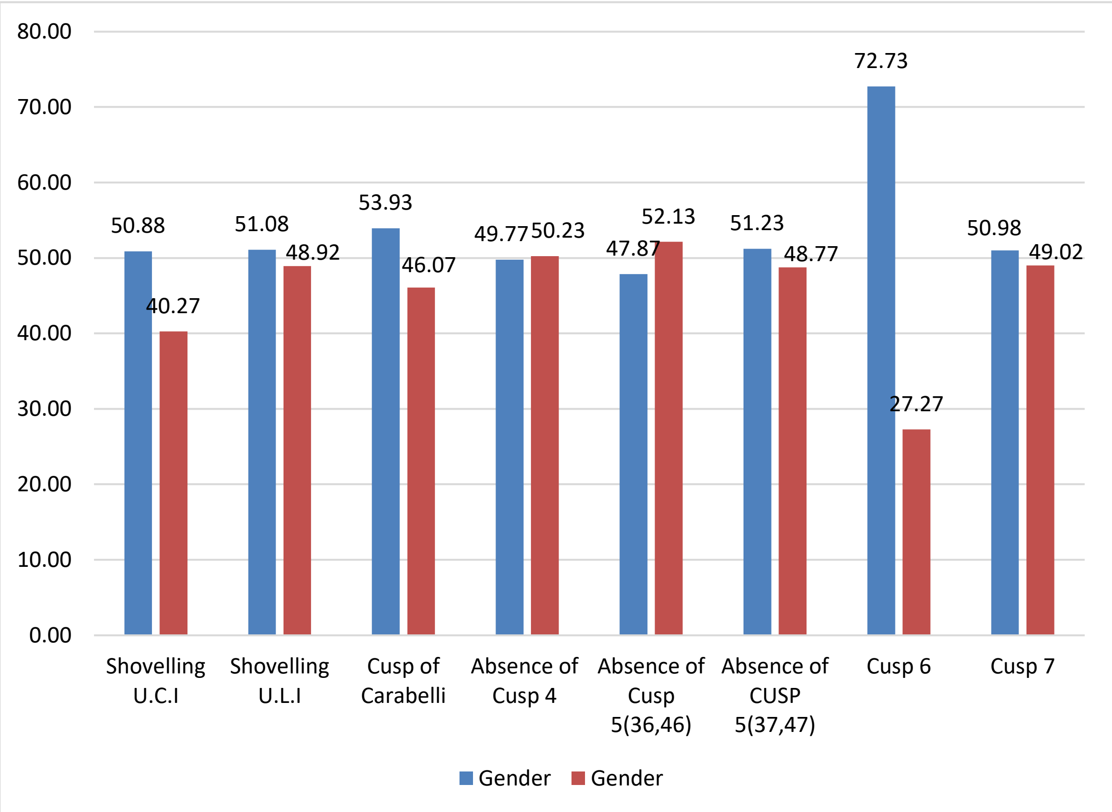


Table13: Inter observers' calibration in assessment to mandible casts by Weighted Kappa statistic.

Mandible	Agreement	Kappa	Std. Err.	Z-value	p-value
31MD	97.56%	0.9248	0.0913	10.1300	0.0001*
31BL	99.19%	0.9743	0.0893	10.9100	0.0001*
32MD	98.77%	0.9629	0.0897	10.7300	0.0001*
32BL	98.69%	0.9595	0.0902	10.6300	0.0001*
33MD	98.42%	0.9503	0.0881	10.7900	0.0001*
33BL	98.44%	0.9523	0.0896	10.6300	0.0001*
34MD	98.72%	0.9590	0.0871	11.0100	0.0001*
34BL	98.64%	0.9577	0.0896	10.6900	0.0001*
35MD	98.74%	0.9630	0.0910	10.5800	0.0001*
35BL	99.06%	0.9716	0.0901	10.7800	0.0001*
36MD	99.13%	0.9723	0.0877	11.0900	0.0001*
36BL	99.20%	0.9777	0.0934	10.4700	0.0001*
37MD	99.21%	0.9765	0.0918	10.6300	0.0001*
37BL	99.29%	0.9786	0.0911	10.7400	0.0001*
41MD	99.04%	0.9716	0.0902	10.7700	0.0001*
41BL	99.39%	0.9823	0.0913	10.7600	0.0001*
42MD	99.09%	0.9733	0.0923	10.5500	0.0001*
42BL	99.24%	0.9778	0.0927	10.5500	0.0001*
43MD	99.60%	0.9873	0.0885	11.1600	0.0001*
43BL	99.54%	0.9866	0.0928	10.6300	0.0001*
44MD	99.44%	0.9833	0.0905	10.8700	0.0001*
44BL	99.56%	0.9869	0.0912	10.8200	0.0001*
45MD	99.37%	0.9810	0.0890	11.0200	0.0001*
45BL	99.42%	0.9823	0.0908	10.8200	0.0001*
46MD	98.90%	0.9669	0.0898	10.7700	0.0001*
46BL	99.08%	0.9727	0.0918	10.6000	0.0001*
47MD	99.52%	0.9855	0.0900	10.9500	0.0001*
47BL	99.22%	0.9757	0.0877	11.1300	0.0001*

*p<0.05

Inter-observer variation: Table displays the inter-observer variation for mandible teeth for metric assessment using the Weighted Kappa statistic, which measures the level of agreement between observers. The agreement ranges from 97.56% to 99.60%. The (p-values <0.001), suggesting statistically significant agreement among the observers.

Table14: Interobservers calibration in assessment to Maxilla casts by Weighted Kappa statistic

Maxilla	Agreement	Kappa	Std. Err.	Z-value	p-value
11MD	99.06%	0.9709	0.0896	10.8400	0.0001*
11BL	99.14%	0.9746	0.0923	10.5600	0.0001*
12MD	99.09%	0.9738	0.0913	10.6600	0.0001*
12BL	99.38%	0.9805	0.0887	11.0600	0.0001*
13MD	99.39%	0.9814	0.0894	10.9800	0.0001*
13BL	99.44%	0.9834	0.0918	10.7100	0.0001*
14MD	99.20%	0.9757	0.0901	10.8200	0.0001*
14BL	99.36%	0.9795	0.0885	11.0600	0.0001*
15MD	99.39%	0.9819	0.0899	10.9200	0.0001*
15BL	99.48%	0.9844	0.0900	10.9400	0.0001*
16MD	98.57%	0.9585	0.0934	10.2600	0.0001*
16BL	99.57%	0.9870	0.0900	10.9700	0.0001*
17MD	99.57%	0.9872	0.0906	10.8900	0.0001*
17BL	99.56%	0.9868	0.0907	10.8800	0.0001*
21MD	99.67%	0.9905	0.0929	10.6600	0.0001*
21BL	99.40%	0.9821	0.0910	10.7900	0.0001*
22MD	99.56%	0.9863	0.0902	10.9300	0.0001*
22BL	99.43%	0.9827	0.0903	10.8900	0.0001*
23MD	99.52%	0.9863	0.0931	10.5900	0.0001*
23BL	99.60%	0.9881	0.0908	10.8800	0.0001*
24MD	99.44%	0.9828	0.0905	10.8600	0.0001*
24BL	99.56%	0.9866	0.0909	10.8500	0.0001*
25MD	99.63%	0.9883	0.0899	10.9900	0.0001*
25BL	99.53%	0.9865	0.0930	10.6000	0.0001*
26MD	99.26%	0.9792	0.0948	10.3300	0.0001*
26BL	99.65%	0.9896	0.0916	10.8000	0.0001*
27MD	99.66%	0.9894	0.0889	11.1300	0.0001*
27BL	99.63%	0.9887	0.0900	10.9800	0.0001*

*$p<0.05$

Inter-observer variation: Table displays the inter-observer variation for maxilla teeth for metric assessment using the Weighted Kappa statistic, which measures the level of agreement between observers. The agreement ranges from 98.57% to 99.67%. The (p-values <0.001), suggesting statistically significant agreement among the observers

Table15: Intra observer's calibration in assessment to mandible casts by Weighted Kappa statistic

Mandible	Agreement	Kappa	Std. Err.	Z-value	p-value
31MD	97.01%	0.9075	0.0910	9.9700	0.0001*
31BL	98.72%	0.9601	0.0890	10.7900	0.0001*
32MD	98.22%	0.9464	0.0900	10.5100	0.0001*
32BL	98.59%	0.9554	0.0887	10.7800	0.0001*
33MD	98.39%	0.9485	0.0874	10.8600	0.0001*
33BL	98.59%	0.9564	0.0889	10.7600	0.0001*
34MD	98.66%	0.9569	0.0872	10.9700	0.0001*
34BL	98.54%	0.9549	0.0902	10.5900	0.0001*
35MD	98.69%	0.9615	0.0907	10.6000	0.0001*
35BL	98.58%	0.9571	0.0900	10.6300	0.0001*
36MD	98.80%	0.9627	0.0885	10.8800	0.0001*
36BL	98.75%	0.9652	0.0952	10.1400	0.0001*
37MD	99.02%	0.9709	0.0921	10.5400	0.0001*
37BL	98.86%	0.9659	0.0914	10.5700	0.0001*
41MD	98.71%	0.9613	0.0896	10.7300	0.0001*
41BL	99.24%	0.9775	0.0907	10.7800	0.0001*
42MD	98.74%	0.9631	0.0915	10.5300	0.0001*
42BL	99.02%	0.9704	0.0905	10.7200	0.0001*
43MD	99.23%	0.9761	0.0890	10.9600	0.0001*
43BL	99.24%	0.9778	0.0930	10.5200	0.0001*
44MD	98.92%	0.9669	0.0892	10.8400	0.0001*
44BL	99.33%	0.9795	0.0901	10.8700	0.0001*
45MD	98.94%	0.9685	0.0897	10.7900	0.0001*
45BL	99.11%	0.9727	0.0915	10.6300	0.0001*
46MD	98.68%	0.9610	0.0909	10.5700	0.0001*
46BL	99.12%	0.9735	0.0909	10.7100	0.0001*
47MD	99.45%	0.9833	0.0899	10.9400	0.0001*
47BL	98.96%	0.9672	0.0871	11.1000	0.0001*

*p<0.05

Intra-observer variation: Table displays the intra-observer variation for mandible teeth for metric assessment using the Weighted Kappa statistic, which measures the level of agreement between observers. The agreement ranges from 97.01% to 99.45%. The (p-values <0.001), suggesting statistically significant agreement among the observers

Table16: Intra observer's calibration in assessment to Maxilla casts by Weighted Kappa statistic

Maxilla	Agreement	Kappa	Std. Err.	Z-value	p-value
11MD	98.87%	0.9638	0.0881	10.9400	0.0001*
11BL	99.09%	0.9736	0.0928	10.4900	0.0001*
12MD	98.92%	0.9677	0.0904	10.7100	0.0001*
12BL	99.08%	0.9716	0.0883	11.0100	0.0001*
13MD	98.99%	0.9695	0.0905	10.7200	0.0001*
13BL	99.35%	0.9807	0.0902	10.8700	0.0001*
14MD	99.03%	0.9704	0.0905	10.7200	0.0001*
14BL	99.17%	0.9748	0.0911	10.7000	0.0001*
15MD	99.14%	0.9747	0.0907	10.7500	0.0001*
15BL	99.11%	0.9731	0.0895	10.8700	0.0001*
16MD	98.17%	0.9466	0.0925	10.2300	0.0001*
16BL	99.31%	0.9784	0.0890	10.9900	0.0001*
17MD	99.37%	0.9809	0.0907	10.8200	0.0001*
17BL	99.38%	0.9815	0.0910	10.7900	0.0001*
21MD	99.28%	0.9790	0.0914	10.7100	0.0001*
21BL	99.11%	0.9734	0.0914	10.6500	0.0001*
22MD	99.29%	0.9776	0.0884	11.0600	0.0001*
22BL	99.15%	0.9748	0.0913	10.6700	0.0001*
23MD	99.18%	0.9759	0.0918	10.6300	0.0001*
23BL	99.37%	0.9806	0.0896	10.9400	0.0001*
24MD	99.13%	0.9739	0.0914	10.6500	0.0001*
24BL	99.17%	0.9749	0.0904	10.7800	0.0001*
25MD	99.28%	0.9770	0.0894	10.9200	0.0001*
25BL	99.17%	0.9762	0.0936	10.4300	0.0001*
26MD	99.07%	0.9729	0.0917	10.6100	0.0001*
26BL	99.36%	0.9815	0.0926	10.6000	0.0001*
27MD	99.37%	0.9802	0.0887	11.0600	0.0001*
27BL	99.35%	0.9807	0.0916	10.7000	0.0001*

*p<0.05

Intra-observer variation: Table displays the intra-observer variation for maxilla teeth for metric assessment using the Weighted Kappa statistic, which measures the level of agreement between observers. The agreement ranges from 98.17% to 99.38%. The (p-values <0.001), suggesting statistically significant agreement among the observers.

DISCUSSION

Forensic odontology and its role in human identification:

Forensic odontology (FO) involves using dental knowledge and techniques to assist in legal investigations.[105] Distinctive characteristics of a person's teeth can aid in identifying a deceased individual. This is done by comparing dental information collected after death with dental records obtained before death.[107] Dental identification plays a crucial role in mass disaster situations where remains are often severely fragmented, as teeth may be the only surviving structures suitable for identification. DNA analysis from dental tissue is also valuable in confirming identity, since tooth enamel—the hardest substance in the human body—offers protection to the mitochondrial DNA within, preserving it as a reliable source of genetic material.[105,108]

Forensic odontology is essential in determining age, sex, and ancestry, making it a key component in identifying individuals within forensic science. A crucial step in this process is creating a post-mortem dental profile, which helps narrow down potential matches. This profile is developed by analysing morphological traits—both measurable (metric) and non-measurable (non-metric)—found in the teeth.[110] Teeth, being highly durable and resistant to decomposition, often remain intact long after other tissues deteriorate, making them reliable for identification purposes.[137] Age estimation is commonly performed by analysing tooth development and eruption patterns in children, while dental wear, pulp-to-tooth ratio, and root transparency are used for adults.[138] These methods help narrow down the potential age range of an individual, aiding in identifying unknown victims or resolving age-related legal disputes.[139] In terms of sex estimation, dental characteristics exhibit subtle but measurable sexual dimorphism. Males generally have larger teeth, particularly the canines, which makes canine size analysis a useful tool in distinguishing biological sex.[140] Additionally, enamel thickness and crown dimensions can provide further clues.[141] Ancestry estimation relies on the identification of population-specific dental traits. For example, shovel-shaped incisors are more prevalent in Asian and Native American populations, while Carabelli's cusp is commonly seen in individuals of European descent.[142] DNA extraction from teeth further enhances ancestry estimation by identifying genetic markers linked to specific populations.[143] Forensic odontology is widely applied in criminal investigations, mass disaster victim identification, and missing persons cases, providing critical biological data when skeletal or soft tissue evidence is unavailable.[144] Despite its significance, challenges such as individual variability in dental wear, mixed ancestry traits, and the subjective nature of bite mark analysis can affect accuracy. Nevertheless, forensic odontology remains a powerful and reliable method in modern forensic science, contributing significantly to the identification and profiling of individuals.

Metric traits for forensic identification:

Odontometry, a branch of anthropology dating back to the early 1700s, involves the study of dental measurements to distinguish between various groups and populations. In forensic dentistry, it is instrumental in the identification of individuals, while in clinical practice, it aids in planning effective dental treatments.[54]

Analysing dental morphology for identifying sexual dimorphism known as a well-established method in both anthropological and biological research. In FO, this technique is particularly useful for determining gender from the fragmented jaws & teeth. As early as 1938, Buthz &Ehrhardt showed that sexual differences in human dentition could be assessed through crown measurements of secondary dentition. Typically, male teeth are larger than female teeth.[67]

Metric traits for sex determination:

Determining sex is a crucial part of developing a biological index, as it helps reduce the number of possible matches by excluding individuals of the opposite sex.[119] Differences between male and female skeletal and dental features arise due to sex hormones effects.[121] Within same inhabitants, males &females exhibit variations of tooth variation (size, shape, and structure); however, the extent of dental sexual dimorphism can differ across divergent populations.[81,71,121,122]

Odontometric (MT) methods involve measuring specific anatomical landmarks on the teeth and jawbones, with the collected data subjected to statistical analysis. Traditionally, odontometric techniques have been applied to estimate both an individual's sex & age. [123,124] Tooth measurements are typically taken using fine-point vernier/digital calliper's, focusing on dimensions such as BL, MD, and occluso-cervical (crown height). Studies have consistently shown that male teeth are generally larger than female teeth, though the extent of these differences can vary between populations.[81] Despite population-specific variations, such data are valuable for sex estimation in both individual identification and mass fatality situations.[49,81,125,126] Among all teeth, mandibular canine is frequently identified as the most sexually dimorphic in human dentition.[67]Tooth size differences between individuals (males &females) have been studied for decades, with numerous reports available from a wide range of countries and population groups.[81,60,145,146]

This study was undertaken to establish population-specific standards for four ethnic groups of Assam—Kachari, Mising, Bodo, and Deori—to aid in determining the ancestry and/or sex of unidentified individuals from these communities. A total of 808 dental casts were analyzed, comprising 404 maxillary and 404 mandibular casts. The Bodo group included 206 individuals (104 males and 102 females), while the Mising group consisted of 122 participants (60 males and 62 females). The Deori population sample comprised 39 individuals (20 males and 19 females), and the Kachari group included 37 individuals (21 males and 16 females). In the absence of published studies on the Assamese population, we conducted an investigation of dental metric trait dimensions and seven non-metric traits in a sample of 404 individuals.

Interestingly, research focusing on sexual dimorphism in tooth measurements among South Asians—particularly Indians—has only gained attention more recently. Over twenty years ago, Rao et al. documented sexual dimorphism in an Indian population, though their study was limited to measuring the mandibular canines mesio-distal (MD) dimension.[147]Comprehensive studies analyzing all teeth only began appearing in the past decade. However, these investigations were based on relatively small sample sizes and, notably, revealed lower levels of sexual dimorphism compared to populations of European, Sub-Saharan African, Australian Aboriginal, and Native American descent.[148,149]

Among the 5,656 maxillary teeth analyzed in the study, most dimensions were found to be significantly larger in males than in females, demonstrating sexual dimorphism ($p < 0.05$). Interestingly, reverse dimorphism was observed in teeth

15MD, 24MD, and 25MD, where dimensions were greater in females; however, these differences were not statistically significant (Table 3).

Similarly, analysis of 5,656 mandibular teeth revealed that most measurements were also greater in males, with statistically significant differences observed in dimensions of 34BL, 37BL, 41MD, 43MD, 44MD, 44BL, and 46BL ($p < 0.05$). Instances of reverse dimorphism were noted in teeth 35MD and 45MD, where female dimensions exceeded those of males, although these differences were not statistically significant (Table 4).

Out of total of 11312 maxillary and mandibular teeth included in the study, we found most of the combined dimensions were larger in male as compared to females. The combination of dimensions of 15,35MD, 24,42BL,24,44MD, 25,45MD,27,47BL were larger in females showing reverse dimorphism ($p>0.05$ NS). A statistically significant difference was seen between male and females with combined maxillary and mandibular parameters in canines and molars using the independent sample's t-test. (Table 5).

Two of these studies also documented instances of reverse sexual dimorphism, where certain tooth measurements found, on average, larger in females.[82,149] Similar findings have been observed in inhabitants as well, though these studies were all based on relatively sample sizes that are less, typically ranging 57-161 individuals.[150,151]

In our study the accuracy for the LRA (logistic regression analysis) for teeth in maxillary jaw when used for sex identification was 63.40% and accuracy of mandibular was 61.10% (Table7). The accuracy when using both the jaws for sex identification was 61.80%. Punnya VA et al. examined a South Indian population, reporting sex determination accuracy of 68.8% for the maxilla, 74% for the mandible, and 74.8% overall which is slight higher than present study outcome. They used dimensions (MD &BL) of 28 teeth excluding 3rd molars. The results show moderate accuracy, with the mandible being slightly more reliable.[61]Rani et al. conducted their research on a Mysorean Indian population, reporting a sex determination accuracy of 78.8% for the maxilla, while the mandible showed no accuracy (0%). The overall accuracy ranged from 66-78%. The research employed buccolingual (BL) measurements for all teeth, excluding the third-molars. The findings suggest that the maxilla exhibits stronger sexual dimorphism in this population, making it a more reliable indicator for sex determination compared to the mandible.[75] Wankhede et al. examined an Ahmednagar Indian population and found moderate accuracy rates, with the maxilla at 69%, the mandible at 66%, and an overall accuracy of 68% which are in accordance to present research. They used the buccolingual dimensions of all teeth, excluding the third molars. The similar accuracy rates for both jaws indicate relatively balanced sexual dimorphism, making both maxillary and mandibular teeth effective for sex determination.[77]

Yadav et al. conducted their study on an Indian population, reporting 0% accuracy for both the maxilla and mandible, but an overall accuracy of 62.7%. The study measured the dimensions (MD&BL) of 28 teeth, excluding the third molars. Despite the lack of accuracy in individual jaws, the combined measurements provided moderate reliability, highlighting the potential of using overall dental dimensions rather than specific jaws for sex determination.[78]

More et al. conducted their study on an Indian population, reporting sex determination accuracy of 64% for the maxilla, 66.2% for the mandible, and 65.25% overall complementing our results. They used MD and BL dimensions of teeth 16, 26, 36, and 46. The similar accuracy rates for both jaws suggest balanced sexual dimorphism in this population.[73]

In a study conducted on an Indian population, Acharya et al. reported 0% accuracy for the maxilla, 65.7% for the mandible, and the same overall accuracy. They measured MD dimensions of tooth 43. The findings highlight moderate reliability for sex determination using mandibular teeth, while the maxilla was ineffective.[71]

Soundarya et al. conducted their research on a South Indian population, reporting maxillary accuracy of 81%, mandibular accuracy of 72%, and an overall accuracy of 81% which are higher than present result. They measured BL and MD size of upper & lower central incisors, canines & first molars. The results indicate that maxillary teeth exhibit slightly stronger sexual dimorphism than mandibular teeth.[76]Narang et al. studied a North Indian population, reporting maxillary accuracy of 67.5%, mandibular accuracy of 88%, and overall accuracy ranging from 67.5-88%. They measured MD and BL dimensions of teeth 16, 26, 36, and 46. The higher accuracy for mandibular teeth indicates stronger sexual dimorphism in the mandible in this population.[74]

Other studies like that by Khamis et al. studied a Malaysian population and reported sex determination accuracy of 71.5% for the maxilla, 76.5% for the mandible, and an overall accuracy of 78.5%. They used Mesiodistal (MD) and buccolingual (BL) measurements were taken for all teeth, with the exception of the third molars. The study indicates that both jaws show moderate to high accuracy, with the mandible being slightly more reliable.[157] Iqbal et al. conducted their study on a Chinese population, reporting 0% accuracy for the maxilla but a significant 76.8% accuracy for the mandible, with the same overall accuracy. The study measured MD dimensions of teeth 36 and 46. The findings indicate stronger sexual dimorphism in mandibular teeth compared to the maxilla in this population.[156]Adams et al. studied a Japanese population and reported maxillary accuracy ranging from 70-75%, mandibular accuracy between 70-80%, and an overall accuracy of 77.3 - 80.3%. They measured MD and BL dimensions of several teeth, including 11, 21, 14, 24, 32, 42, 34, 44, 36, and 46. The consistent accuracy for both jaws demonstrates balanced sexual dimorphism, making both maxillary and mandibular teeth reliable for sex determination.[158]

In another study conducted on a Nepalese population, Acharya et al. reported 0% accuracy for the maxilla, 69.1% for the mandible, and the same overall accuracy. The study used MD dimensions of teeth 33 and 43. The results indicate moderate reliability in using mandibular teeth for sex determination, while the maxilla showed no accuracy.[68]

El Dosoky et al. studied an Egyptian population and found that maxillary teeth were effective for sex determination, with an accuracy of 74-78%, while the mandible showed no accuracy (0%). The overall accuracy ranged from 72-75%, using dimensions MD&BL were taken for 28 teeth, with the exception of the third molars. The results suggest that maxillary teeth display stronger sexual dimorphism in this population.[79]

Eboh et al. conducted their research on the Uuhobo population in South Nigeria, reporting a maxillary accuracy of 69%, while the mandible showed no accuracy. The overall accuracy was 69%, based on Mesiodistal (MD) and buccolingual (BL) of both the maxillary molars excluding third molars. The study indicates that only maxillary molars are reliable for sex determination in this population, while mandibular teeth are ineffective.[80]

Iscan et al. studied a Turkish population and reported sex determination accuracy of 77% for the maxilla, 75% for the mandible, and an overall range of 73-77%. The study used bucco-lingual (BL) assessment of 28 teeth leaving 3rd – molars .

The similar accuracy for both jaws suggests balanced sexual dimorphism, making both maxillary and mandibular teeth reliable for sex identification in this population.[81]

Franco et al. conducted their research on a Portuguese population and found no accuracy for the maxilla but 69.5% accuracy for the mandible, with the same overall accuracy. They measured MD dimensions of teeth 36 and 43. The study indicates that mandibular teeth are more sexually dimorphic and reliable for sex determination in this population.[84]

Another study on Iranian population and reported maxillary accuracy of 87.1%, mandibular accuracy of 78.4%, and an overall accuracy ranging from 78-87.1%. They measured mesio-distal MD and bucco-lingual BL dimensions of 1st & 2nd molars of both the arches. The high accuracy rates reflect strong sexual dimorphism in both jaws.[72]

Zorba et al examining dental sexual dimorphism in contemporary Greek individuals revealed that males had larger teeth ($P < 0.05$) than females, with the canines being the most dimorphic according to discriminant analysis. When compared with findings from other populations, the study showed that European groups tend to exhibit high levels of dental sexual dimorphism, achieving sex classification accuracies of 90%, while Native American populations displayed the least amount of dimorphism.[152] In another study conducted by Zorba et al done on maxillary and mandibular 1st & 2nd molars in Greek population found 81.80% of accuracy.[83]

Cardoso (2010) examined measures in 46 young skeletons deciduous teeth and discovered that the cross-validated sex classification accuracy was generally relatively low (46.2 - 60%). [153]

Due to the lack of sexual dimorphism in deciduous crowns and the prepubescent skeleton as a whole, this categorisation accuracy is low.[154,155]

In addition to absolute tooth dimensions, tooth portions are also been explored for sex estimation. 'Acharya and Mainali' (2008) examined secondary dentition 123 inhabitants (65 males & 58 females) aged ranged 19-28 yrs. They calculated three dental indices: the crown index, area, and module which yielded sex classification accuracies ranging from 69.8% to 81.1%. However, they noted that these results were less accurate than those reported in earlier studies and concluded dental indices offer limited value in forensic sex determination.[82]

All the studies published globally for sexual dimorphism suggest the MD and BL measurements if done accurately are useful indicators for sex determination. These observations are in accordance with our study for the selected ethnic group of Assamese population.

Metric traits for Ethnicity determination:

In our study, comparison of ancestral differences among the four ethnic groups across all parameters revealed that maxillary tooth dimensions were largely consistent, with the exception of tooth 11BL, which showed a statistically significant difference (p = 0.0172) (Table 8). Similarly, mandibular tooth measurements were generally uniform across the groups, except for tooth 45BL, which demonstrated a significant variation (p = 0.0015) (Table 9)

When the comparison of MD & BL dimensions of both the jaws was done the results of our study showed that the combined dimensions of maxilla and mandible are almost uniform for all ethnic groups. Except for 2nd premolars and the 1st molars the BL values of both jaws were different among the groups and were found to be statistically significant (p-0.019) (p-0.035) respectively (Table10). There are no similar studies to comparing ethnicity with tooth size among subgroups of population. Hanihara et al identifies five main findings regarding dental variation among human populations. Australians possess the largest teeth among global populations, like the 'Melanesians, Micronesians, sub-Saharan Africans, & Native Americans'. On the other end of the spectrum, the smallest teeth are found in 'Philippine Negritos, the Jomon/Ainu', and populations from Western Eurasia.. East and Southeast Asians, along with Polynesians, tend to have average-sized teeth. Regarding dental morphology, the most distinctive traits are observed in Europeans, Indigenous peoples of the Americas, and to a certain extent, Australians. Interestingly, East &Southeast Asians display significant dental familiarity with the Africans (Sub-Saharan), setting themselves as an intermediate position when comparing global dental traits. The observed dental patterns closely correspond to genetic and cranial data, confirming the usefulness of dental traits in studying human diversity. Even after accounting for differences in population size and genetic drift, sub-Saharan Africans continue to display distinctive dental traits, consistent with findings from genetic and cranial studies.[128]

Metric traits between the groups:

Our analysis revealed that maxillary tooth dimensions were largely consistent across the ethnic groups, with the exception of the 11BL measurement, which demonstrated a statistically significant difference ($p = 0.0172$)(Table8). Similarly, mandibular tooth dimensions were generally uniform among the groups, apart from the 45BL parameter, which also showed a significant variation ($p = 0.0015$) (Table9). When maxillary and mandibular parameters were assessed in combination, most values remained comparable across ethnicities, except for 2545BL ($p = 0.019$) and 2646BL ($p = 0.035$) (Table10), both of which exhibited statistically significant intergroup differences. Hence there is not much of changes between the groups.

Non-metric traits for forensic identification:

Non-metric dental features can be examined by observing both their presence and the level of their development in different population groups. These characteristics are well-defined and can be measured with relative ease, making them useful for comparative studies.[131] These traits can be evaluated through visual inspection alone, eliminating the need for specialized tools or equipment. A key advantage of using non-metric traits is that, unlike metric approaches, they can still be analyzed even when only partial or fragmented remains are available.[132] Recent advancements in genetics have demonstrated that many traits follow distinct inheritance patterns, allowing for the predictable occurrence of certain characteristics among individuals within specific populations. [133] It is widely recognized that the prevalence of various non-metric skeletal and dental traits differs among populations as a result of genetic diversity.[63] Researchers have suggested that non-metric traits of the cranium and teeth are more valuable for analyzing population variation than postcranial traits, as they tend to be more closely linked to environmental and functional influences.[135]

Non-metric traits for ethnic identification:

Teeth characteristics such as their number, shape, size, structure, and eruption timing are strongly influenced by both environmental and functional factors. These influences include many infections, hormonal changes, nutritional intake, exposure to certain medications and chemicals, fluoride levels in water, and eating habits, particularly the types of food regularly consumed.[5,135] A notable limitation of utilizing non-metric dental traits is that the information is often not quantitatively analyzed, leading to a deficiency in statistical accuracy and robustness.[118] Non-metric (NMt) dental traits are commonly examined by measuring how frequently they appear in a given population. When a particular trait is observed at a high rate within that group, it is viewed as a distinguishing feature of that population.[131] A comprehensive knowledge of the global distribution of various non-metric (NMt) dental traits, along with insights into their hereditary patterns, is essential for forensic dentist's aiming to estimate an individual's sex& estimation of ancestry based on dental evidence. In a study conducted by- Matsumura (1995), 21 non-metric (NMt) traits were analyzed to explore population relationships among 'East Asians, Southeast Asians, Native Americans, and Australian Aborigines'. The findings revealed that Northeast Asians, Native Americans, and Arctic populations create distinct sub-groups within larger cluster believed to have formed from North-east Asia. This cluster was clearly separate from the group consisting of Australian& Melanesian populations..[66]

Turner CG explained dental patterns like Sinodont, Sundadont, and other related dental types, which are patterns of dental morphology used in anthropology to trace population movements and genetic relationships.[94]

Sinodonty is characterized by a specific set of dental traits, including: Shovel-shaped incisors, High frequency of double shoveling, Reduced or absent third molars, Complex root patterns with multiple canals. This dental pattern is primarily found in Northeast Asians, including populations from China, Mongolia, Korea, and Japan. It is also observed in Native Americans, suggesting a link through ancient migration from Asia across the Bering Strait.[94]

Sundadonty represents a different dental pattern with: Less pronounced shovelling of incisors, simpler molar cusp patterns, lower occurrence of double shovelling. It is typically associated with Southeast Asians, including populations from the Philippines, Thailand, and Indonesia. This pattern is considered more archaic, potentially representing the dental morphology of early modern humans in Southeast Asia.[94]Indodont refers to the dental pattern found in South Asian populations. It appears to share some characteristics with both Sinodont and Sundadont patterns, with region-specific traits that reflect gene flow and intermixing .[94]Australomelanesian Dentition which are found in Australian Aboriginals and Melanesians. Key features are large, robust teeth, simplified crown morphology. This pattern reflects the dental characteristics of early human populations in the region[94].Arctic Dentition are associated with Inuit and Aleut populations. Key traits are heavy dental wear, large, robust molars, adaptations for cold-climate diets.[94]

Hanihara described “Mongoloid dental complex” based on findings derived from the study of Japanese, Ainu, &American populations.[102] Brues defined the term "Mongoloid" as encompassing the indigenous populations of East Asia, ranging from the Burmese in the west to the Japanese from east, the Chukchi in north, and the Malays from south. This classification also includes the majority of native groups found throughout Island Southeast Asia and those residing within these geographical boundaries.[103] Kalistu et al highlighted various nonmetric dental traits and their frequency across different racial groups—Mongoloids, Negroids, and Caucasoids. In Mongoloids, several traits occur with high frequency, including shoveling and double shoveling of incisors, the presence of a 5-cusp molar with Y grooves, protostylid, supernumerary teeth, winging of maxillary central incisors, and deflective wrinkles. And moderate frequency traits include the presence of a 7-cusp molar with Y grooves and some degree of dental crowding also low-frequency traits include the Bushman canine/mesial ridge, Carabelli cusp, and peg-shaped teeth.[171]

We included 7 non-metric traits- Shoveling, Carabelli’s cusp, Cusp4 (Hypocone absence), Cusp5 (Hypoconulid absence), Cusp6(Entoconulid) and Cusp7(Metaconulid) to estimate the ancestry. Our results on non-metric dental analysis across the four ethnic groups from Assam, India—Kachari, Bodo, Mising, and Deori—reveals distinct patterns of dental traits, highlighting intergroup variations. The distribution of non-metric dental traits across the population reveals distinct patterns and varying frequencies of occurrence (Table12)

Shoveling in the upper central incisor was observed in 55.94% of the population, making it one of the most frequently occurring traits. Shoveling in the upper lateral incisor was slightly less common but still prominent, occurring in

46.04% of individuals. The results are in accordance with Turner CG et al. reported shovelling frequencies of 73.5%–88.3% in 22, which is higher than our result but still within a comparable range, indicating a shared Sinodont dental pattern which are Northeast Asians populations (China, Mongolia, Korea, and Japan) whereas 26.8-37.2% seen in Southeast Asians (Thailand, Philippines, Malaysia, Indonesia, and Prehistoric Taiwan) and 2.3%- 7.3% in South Asians (Eurpoe & Africa). [94] Sah SK et al. noted a higher prevalence of shovelling in Tibeto-Nepalese, which aligns with your moderate frequency, suggesting shared Asian influences.[92]Kobayashi recorded 55% shovelling in Hani Chinese group indicating Sinodont influence.[97]Brazilian population showed 14.3% shovelling[98], Tamil population showed 8% prevalence[88], Pakistani Punjabi showed 31.2%[100] Sri Lankan Vedda population showed 0% shovelling.[93]

Our study showed Cusp of Carabelli, a characteristic feature of the mesiopalatal-cusp of the upper 1st molar, was present in 22.03% of the population, indicating moderate prevalence which is in accordance with Turner CG et al. study on Northeast Asians populations (China, Japan, Mongolia, Siberia, and Native Americans) that is Carabelli trait (30.9%). He also found Carabelli trait (24.6%–41.9%) moderately in Southeast Asians(Thailand, Philippines, Malaysia, Indonesia, and Prehistoric Taiwan).[94] Slightly lower prevalance in Tinoco et al found a 19.4% Carabelli prevalence in Brazilians[98], Neolithic Maltese populations, with a prevalence of 16.7%[99], Baby et al. reported a 12.9% prevalence in Kerala populations, which is lower than in other Indian groups, possibly due to genetic differences influenced by Dravidian[8] and Higher prevalence in Southern Jordanians noted a 42.1% prevalence in, Luisa et al. found a 51.3% prevalence in Colombian individuals.[91] Srivastav et al. reported a 23% prevalence in Tamil populations, suggesting a moderate occurrence in

South India.[88] Vaishali et al. observed a higher prevalence (33.7%) in Vidarbha Maharashtrian individuals, indicating a possible genetic continuity with ancient South Asian populations.[89] Sah SK et al. found a 35% prevalence in Indo-Nepalese populations, highlighting genetic similarities with South Asian groups.[92] Hassan S et al. documented a 25% prevalence in Kashmiris, lower than in European populations but still significant for South Asia.[101]

The absence of cusp 4 (hypocone) in the maxillary second molar was identified in 54.21% of individuals, suggesting a relatively high frequency of this trait. Consistent with our results Turner reported 66.7% hypocone absence in Northeast Asians (China, Japan, Mongolia, Siberia, and Native Americans) ,50-75% hypocone absence in Southeast Asians (Thailand, Philippines, Malaysia, Indonesia, and Prehistoric Taiwan) and 96.4% South Asians (India, Africa & Europe) indicating consistency with our result of 54.21%, although slightly lower.[94] Peiris HRD et al. reported 93.8% hypocone absence on UM2, making it one of the most frequently occurring dental traits in this population. This remarkably high frequency reflects low Sinodont influence, distinguishing the Sri Lankan Vedda population from East and Southeast Asian groups, which typically display higher hypocone presence.[93] Kobayashi K et al. in Hani Ethnic Group, China observed in 84.1% hypocone absence indicates Sinodont influence which is typical of Northeast Asian populations, where hypocone reduction is common[97]. Tinoco et al. (Brazilian) showed hypocone absence 58.3% suggests a blend of European and Sub-Saharan African ancestry, as both groups exhibit relatively high frequencies of hypocone absence[98], Coppa A et al. in Neolithic Maltese Population depicts moderately lower in UM2 (56.1%) indicates genetic ties to Southern European and North African populations, which display moderate to high occurrences of this trait.[99]

Similarly, the absence of cusp5 (hypoconulid absence) on the mandibular 1st molar (36, 46) was noted in 23.27% of the population, while the absence of cusp 5 on the mandibular second molar (37, 47) was remarkably higher, occurring in 90.35% of individuals. This indicates that cusp 5 absence is far more common in the second molar than in the first. Very similar to our results Tinoco eta al [98] in Brazalian studies showed 83% hypoconulid absence, Baby et al[8] in Kerala population said 7.91% absence of Cusp 5 suggests ethnic differentiation from Colombian and Caucasian populations. Vaishali et al[89] in Maharashtrian population showed high prevalence of cusp 5. Peiris HRD et al[93] in Sri Lankan Vedda population absence cusp 5 in LM1 is 59% ,LM2 is 98%.

Less frequent traits included the presence of cusp6 (Entoconulid) on the lower 1st molar, which was rare, occurring in only 2.72% of the population similar to Hani ethnic chinese people is 7.9% in the study by Kobayashi K et al[97]. Few studies like Rahmeh A et al[95] in Jordanian population showed 17.4%, Tinoco et al[98] in Brazilian population showed 15%. Vaishali et al[89] in Maharashtrian population showed 5-15% prevalence of cusp 6. Baby et al in Kerala population said 1.19% prevalane of cusp 6.[8] Peiris HRD et al[93] in Sri Lankan Vedda population cusp 6 present 40%.

The presence of cusp7, another accessory cusp on the lower jaw first molar, was slightly more common, observed in 12.62% of individuals. Similar to our studies Turner CG et al[94] in Northeast Asians (China, Japan, Mongolia, Siberia, and Native Americans) showed 7.9-11.8%, in Southeast Asians(Thailand, Philippines, Malaysia, Indonesia, and Prehistoric Taiwan) showed 8.5-22.2%, Rahmeh A et al[95] in Jordanian population showed 18.7%.Cusp 7 is very high in Africa (49.3%) but very low in Europe (5.9%).[94] Vaishali et al in Maharashtrian population showed 10-25%

prevalence of cusp .[89] Baby et al in Kerala population said 0 % prevalane of cusp 6.[8] Peiris HRD et al[93] in Sri Lankan Vedda population cusp 7 present 41%.Rahmeh A et al[95] in jordanian population showed 18.7% cusp7 prevalence. Coppa A et al[99] at Neolithic Maltese Population showed Cusp 7 is 3.6%. Kobayashi K et al[97] in Hani chinese population showed 3.41% .

Our study revealed that certain non-metric dental traits—like shoveling, the presence of the cusp of Carabelli, also absence of the hypoconulid—were prominently observed across the four Assamese ethnic groups. These traits are characteristic of Mongoloid populations, indicating a strong genetic affinity. The findings suggest that these groups may share ancestral links with Mongoloid populations, which is possibly also reflected in their craniofacial features resembling those of Northeast Asian and Mongolian populations.

Non-metric traits between the groups

Our study showed shoveling of the upper central incisor was most frequently observed among the Kachari (70.27%), followed by the Bodo (59.22%), Mising (48.36%), and Deori (48.72%) communities, showing statistical significance (p = 0.0540) (Table12). A similar trend was seen in shoveling for upper (LI) lateral incisor, with highest occurrence in Kachari (62.16%), then Bodo (51.46%), Mising (37.70%), and Deori (28.21%), which was also statistically significant (p = 0.0020). Cusp of Carabelli present on the mesiopalatal-cusp of upper first-molar varied among groups, with the highest frequency in Kachari (32.43%), statistically significance is not there in differences (p = 0.4260). Hypocone absence (cusp 4) in the upper second molar was commonly observed in Deori (61.54%), Mising (56.56%), Bodo (55.34%), and Kachari (32.43%), and this finding was statistically significant (p = 0.0400).

Similarly, hypoconulid absence (cusp 5) in the upper first molar was more frequent in Deori (41.03%), followed by Mising (22.13%), Bodo (21.84%), and Kachari (16.22%), also showing significance (p = 0.0410). Within the groups there is not much of a difference though significat difference were evident with shovelling , cusp4 and cusp5. But they shouldn’t be used for differentiating the ethinicity. However these study is not comparable with any other study because no studies have used these particular ethnic groups in the literature.

Non-metric traits for Sex identification

Our study showed none of the non-metric features showed any significant sexual dimorphism but shoveling in central and lateral incisors, cusp of carabelli, absence of cusp 5 in lower 2^{nd} molars, cusp 6 and cusp 7 are more common is males making absence of cusp 4 and absence of cusp 5 in lower 1^{st} molar more common in females (Table11). Our results are in accordance to a review by Heng et al suggested Sex estimation through non-metric (NM) methods involves assessing certain morphological features, focusing on whether these traits are present or absent in both skeletal and soft tissues. Calcified tissue examination focuses on analyzing the structure of teeth and bones is part of dental and skeletal morphology assessment, whereas the examination of soft tissues involves evaluating features such as ‘chieloscopy’ (lip print analysis) &rugoscopy (palatal ridge examination). Unlike metric-traits, involving precise, repeat measures. Non-metric methods are more vulnerable to subjective interpretation by the analyst. Overall, dental morphological traits are generally less sexually dimorphic compared to teeth variables in size. Studies attempting estimation of sex using these features have often shown inconsistent results, frequently favouring either males or females, with no universal consensus.[169]

Scott identified the distal accessory ridge of canine as one sole structural trait in human teeth demonstrating sexual difference.[134] In a different study Scott also perceived variation in the frequency and articulation degree of distal accessory ridge in canine, noting that males exhibited this trait more frequently and with greater prominence than females. However, he also suggested the manifestation of this morphological feature could may be affected by genetic heritage or population variability .[134]

Not in accordance to our study Pillai et al utilized Discriminant Function Analysis (DFA) to estimate sex based on three variables. Among three traits, shovelling proved to be the most effective in predicting both sex and population. Additionally, the study found that females were classified more accurately than males.[90] Adler et al found Carabelli's trait and molar cusp number have an accuracy rate of 70.2% to 74.8% in sex estimation among children.[170]

While non-metric traits have potential for sex estimation, they must be applied with caution due to the risk of subjective error when grading these traits. This highlights the need for thorough training to effectively handle standard plaques and accurately identify expression grades.[90]

Interobserver and intraobserver Agreement

Present study shows a statistically significant level of agreement in dental measurements, with p-values below 0.001, indicating that the consistency observed is extremely unlikely to be the result of chance.

For interobserver variation (consistency between different observers), the agreement is exceptionally high. In the maxilla (upper jaw) teeth, the agreement ranges from 98.57% to 99.67% (Table14), demonstrating near-perfect consistency. Similarly, for the mandible (lower jaw) teeth, the agreement ranges from 97.56% to 99.60% (Table13), highlighting strong reliability across different observers.

When examining intraobserver variation (consistency when the same observer measures the teeth multiple times), the results are equally reliable. For maxilla teeth, the agreement ranges from 98.17% to 99.38% (Table16), while for mandible teeth, it falls between 97.01% and 99.45% (Table15). This reflects a high level of precision and consistency in repeated measurements by individual observers.

The p-values below 0.001 for both interobserver and intraobserver variation confirm the high accuracy and reproducibility of the dental measurements, ensuring the reliability of the data used in the study.

In forensic investigations, particularly those involving large-scale fatalities such as mass disasters, human remains are often severely decomposed or fragmented. In these challenging situations, teeth play a vital role in the identification process due to their high resistance to extreme conditions like explosions and heat, which typically damage other skeletal parts. One widely adopted approach for identifying unknown individuals is forensic profiling, where specialists estimate characteristics such as sex, age, ancestry, and height based on skeletal evidence. In recent years, significant research has been devoted to advancing these identification techniques.[159,160,161,162] has concentrated on creating a range of population-specific repository that measure and document variations in dental anatomy and tooth structures.

The primary purpose of developing these databases, to support the identification of unidentified human remains. These population-specific records enhance our understanding of morphological differences among various ancestral and ethnic groups, offering valuable insights for forensic investigations. Since the occurrence and expression of dental anomalies differ across populations, they can serve as indicators of an individual's sex and ancestral background. [163,164,165,166,167,168]

Concerning the four populations analyzed in this study, there is a lack of existing research on the prevalence of dental (metric & non-metric) traits among ethnic population of assam.

The present thesis has resulted in the creation of a comprehensive database that captures detailed information about population characteristics specifically related to dental traits.

This database serves as a valuable resource for our country, as it can aid in the development of a dental profile that reflects the prevalence, types, and distribution of these traits. By doing so, the thesis addresses a previously unexplored or insufficiently documented areas of Assam India, thereby contributing new insights and filling a gap in the existing body of knowledge on population characteristics aiding to Forensic odontology.

SUMMARY AND CONCLUSION

- The current research presents reference values regarding the frequency of metric and non-metric dental trait in Assamese populations of Northeast India, which can aid in determining an individual's sex and/or ancestral background.
- We found LRA of maxilla teeth is 63.40% and mandibular teeth 61.10%. The total accuracy when using both the jaws for sex identification was 61.80% which is moderate accuracy and can be used as adjunct along with skull and other parameters.
- Metric traits of maxilla and mandible dimensions combined are almost uniform for all ethnic groups. There are no similar studies to comparing ethnicity with tooth size among subgroups of population
- Metric traits showed no significant differences among the ethnic groups for sex determination and estimation of ancestry did not help in adding a definite conclusion.
- Non metric traits frequency in our population showed shoveling in upper central incisors 55.94%, shoveling in upper lateral incisors 46.04%, Cusp of Carabelli is 22.03%, absence of cusp 4 is 54.21%, absence of cusp 5 in lower first molars 23.27%, absence of cusp 5 in lower second molars is 90.35%, cusp 6 present is 2.72% and cusp 7 is 12.62%. which is very close to that of Northeast Asians and South east Asians populations but predominantly Mongoloids. Few of the features like cusp of carabelli are similar to that of Indians.
- Our study also showed none of the non-metric features showed any significant sexual dimorphism but shoveling in central and lateral incisors, cusp of

carabelli, absence of cusp 5 in lower 2nd molars, cusp 6 and cusp 7 are more common is males making absence of cusp 4 and absence of cusp 5 in lower 1st molar more common in females.

- Non metric traits between the ethnic groups there is not much of a difference though significat difference were evident with shovelling , cusp4 and cusp 5. But they shouldn't be used for differentiating the ethinicity. However these study is not comparable with any other study because no studies have used these particular ethnic groups in the literature.
- In general, we can identify that a individual is Assamese but cannot identify what ethnicity they belong to because there is no much significant difference in non-metric traits among the ethnic groups .

LIMITATIONS

i) The sample size used in this study may be considered a limiting factor. Since there are many more ethnic groups in Assam which can be added up by increasing the sample size.

ii) Only seven non-metric traits were included in this study. Incorporating a larger number of non-metric traits could enhance the dataset's potential for applications in racial profiling or ancestry estimation.

iii) The present study utilized dental casts as the primary material for analysis. However, the accuracy of trait evaluation can be influenced by the quality of these casts.

FUTURE SCOPE:

This thesis utilized established assessment protocols and definitions from prior research. However, further studies are needed to develop a standardized approach for evaluating dental variation. It is advised that future research include larger and more diverse population samples, enabling more accurate quantification of dental trait frequencies through rigorous statistical analysis and consistent assessment methods. Additionally, with proper ethical approval, intentionally creating dental casts from living individuals—alongside the collection of relevant demographic details and population backgrounds—would enhance the reliability of findings and contribute to stronger forensic identification standards.

‘Potential practical forensic applications’

This study was conducted to establish non-metric dental standards—specifically, frequency data on dental variations—for four ethnically distinct Assamese groups. The findings demonstrate that certain dental traits, such as Shoveling, absence of the hypocone, lack of hypoconulid, and presence of cusp 7, appeared consistently across these populations. As such, the statistical data generated may serve as a preliminary tool for suggesting Mongoloid ancestry in unidentified individuals. However, these results are best interpreted in conjunction with existing related studies; collectively, such data can contribute to a more comprehensive statistical framework for assessing dental traits in unknown remains, ultimately aiding in the determination of potential ancestry and, subsequently, gender.

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ANNEXURES

ANNEXURE – I

CONSENT FORM & PATIENT INFORMATION SHEET:

Department of Oral and Maxillofacial Pathology and Oral Microbiology KAHER'S KLE'S V.K. INSTITUTE OF DENTAL SCIENCES, BELAGAVI

INFORMED CONSENT FORM

TITLE: Evaluation of Metric & Non-Metric Dental Features In Four Ethnic Groups Of Assamese Population For Forensic Profiling

PRINCIPAL INVESTIGATOR:

I, ________________________________, aged ________ years have been informed about my involvement in the study.

- I agree to give my personal details like Name, Age, Gender, Residential Address, Ethnicity, Previous and Present dental history and any other details if required for the study to the best of my knowledge.
- I have been explained about this study and my participation in the study in my language.
- I agree to be part of the study after understanding my role for the same.
- I will co-operate & consent for taking impression of both maxilla & mandible.
- I will follow the instructions given by Dr Bidisha during the study.
- I permit her to utilize the information given and results obtained from this study for presentation and publication without disclosing my identity.
- I have understood the nature of the study and permit the Dr Bidisha to collect dental records.
- I will not claim any returns for participation in this study, even if it is being sponsored by any agency. I am participating with my own will and wish.
- If for any reason I am unable to participate in the study, for reasons unknown, I am permitted to withdraw from the study.
- In my full consciousness and presence of mind, after understanding all the procedures and related complications if any, in my vernacular language, I am willing and give my consent to participate in this study.

Date:

Address & Ph. No:

Signature:

ANNEXURE – II

ओरल और मैक्सिलोफेशियल पैथोलॉजी और ओरल माइक्रोबायोलॉजी विभाग
KAHER'S KLE'S V.K. दंत चिकित्सा विज्ञान संस्थान, बेलगावी
सूचित सहमति प्रपत्र

शीर्षक: फॉरेंसिक प्रोफाइलिंग के लिए असमिया आबादी के चार जातीय समूहों में मीट्रिक और गैर-मीट्रिक दंत चिकित्सा सुविधाओं का मूल्यांकन

प्रधान अन्वेषक:

मुझे, ______________________________, आयु _______ वर्ष अध्ययन में मेरी भागीदारी के बारे में सूचित किया गया है।

• मैं अपने व्यक्तिगत विवरण जैसे नाम, आयु, लिंग, आवासीय पता, जातीयता, पिछला और वर्तमान दंत चिकित्सा इतिहास और कोई अन्य विवरण यदि मेरी जानकारी के अनुसार अध्ययन के लिए आवश्यक हो तो देने के लिए सहमत हूं।

• मुझे इस अध्ययन और अध्ययन में मेरी भागीदारी के बारे में मेरी भाषा में समझाया गया है।

• मैं इसके लिए अपनी भूमिका को समझने के बाद अध्ययन का हिस्सा बनने के लिए सहमत हूं। मैं मैक्सिला और मैंडिबल दोनों के लिए अपने संपूर्ण प्रभाव के लिए सहयोग और सहमति दूंगा।

• मैं अध्ययन के दौरान डॉ बिदिशा द्वारा दिए गए निर्देशों का पालन करूंगा।

• मैं उसे अपनी पहचान प्रकट किए बिना प्रस्तुति और प्रकाशन के लिए दी गई जानकारी और इस अध्ययन से प्राप्त परिणामों का उपयोग करने की अनुमति देता हूं।

• मैंने अध्ययन की प्रकृति को समझ लिया है और डॉ बिदिशा को डेंटल रिकॉर्ड एकत्र करने की अनुमति दी है।

• मैं इस अध्ययन में भाग लेने के लिए किसी रिटर्न का दावा नहीं करूंगा, भले ही इसे किसी एजेंसी द्वारा प्रायोजित किया जा रहा हो। मैं अपनी इच्छा और इच्छा से भाग ले रहा हूं।

• यदि किसी कारणवश मैं अज्ञात कारणों से अध्ययन में भाग लेने में असमर्थ हूँ, तो मुझे अध्ययन से हटने की अनुमति है।

• अपनी पूरी चेतना और दिमाग की उपस्थिति में, सभी प्रक्रियाओं और संबंधित जटिलताओं को समझने के बाद, मेरी स्थानीय भाषा में, मैं इस अध्ययन में भाग लेने के लिए तैयार हूं और अपनी सहमति देता हूं।

तारीख:
पता और फोन नंबर:
हस्ताक्षर:

ANNEXURE – III

মৌখিক আৰু মেক্সিলোফেচিয়েল পেথ'লজি আৰু মৌখিক অণুজীৱবিজ্ঞান বিভাগ KAHER'S KLE'S V.K. দন্ত বিজ্ঞান প্ৰতিষ্ঠান, বেলাগাভি

জ্ঞাত সন্মতি প্ৰ-পত্ৰ

TITLE: ফৰেনছিক প্ৰফাইলিঙৰ বাবে অসমীয়া জনসংখ্যাৰ চাৰিটা জনগোষ্ঠীত মেট্ৰিক আৰু নন-মেট্ৰিক দন্ত চিকিৎসাৰ বৈশিষ্ট্যৰ মূল্যায়ন

প্ৰধান তদন্তকাৰী: ড. বিদিশা বৰা

মই, ________________________________, বয়স ________ বছৰ অধ্যয়নত মোৰ জড়িততাৰ বিষয়ে অৱগত কৰা হৈছে।

• মই মোৰ ব্যক্তিগত তথ্য যেনে নাম, বয়স, লিংগ, আৱাসিক ঠিকনা, জাতি, পূৰ্বৰ আৰু বৰ্তমানৰ দন্ত চিকিৎসাৰ ইতিহাস আৰু অধ্যয়নৰ বাবে প্ৰয়োজন হ'লে অন্যান্য যিকোনো তথ্য মোৰ জ্ঞাতসাৰে দিবলৈ সন্মত।

• এই অধ্যয়ন আৰু অধ্যয়নত মোৰ অংশগ্ৰহণৰ বিষয়ে মোক মোৰ ভাষাত বুজাই দিয়া হৈছে।

• একেটাৰ বাবে মোৰ ভূমিকা বুজি পোৱাৰ পিছত মই অধ্যয়নৰ অংশ হ'বলৈ সন্মত হওঁ।

• মই মেক্সিলা আৰু মেণ্ডিবল দুয়োটাৰে বাবে মোৰ সম্পূৰ্ণ ইম্প্ৰেছন মেকিংৰ বাবে সহযোগিতা আৰু সন্মতি দিম।

• অধ্যয়নৰ সময়ত ডাঃ বিদিশাই দিয়া নিৰ্দেশনা মানি চলিম।

• এই অধ্যয়নৰ পৰা দিয়া তথ্য আৰু পোৱা ফলাফলসমূহ মোৰ পৰিচয় প্ৰকাশ নকৰাকৈয়ে উপস্থাপন আৰু প্ৰকাশৰ বাবে ব্যৱহাৰ কৰিবলৈ মই তাইক অনুমতি দিওঁ।

• অধ্যয়নৰ প্ৰকৃতি বুজি পাই ডাঃ বিদিশাক দন্ত চিকিৎসাৰ ৰেকৰ্ড সংগ্ৰহ কৰিবলৈ অনুমতি দিছো।

• এই অধ্যয়নত অংশগ্ৰহণৰ বাবে মই কোনো ধৰণৰ ৰিটাৰ্ণ দাবী নকৰো, যদিও ইয়াক কোনো সংস্থাই পৃষ্ঠপোষকতা কৰিছে। নিজৰ ইচ্ছা আৰু ইচ্ছাৰে অংশগ্ৰহণ কৰিছো।

• যদি কোনো কাৰণত মই অধ্যয়নত অংশগ্ৰহণ কৰিব নোৱাৰো, অজ্ঞাত কাৰণত, তেন্তে মোক অধ্যয়নৰ পৰা আঁতিৰি আহিবলৈ অনুমতি দিয়া হৈছে।

• মোৰ সম্পূৰ্ণ চেতনা আৰু মনৰ উপস্থিতিত, সকলো পদ্ধতি আৰু আনুষংগিক জটিলতা যদি আছে, মোৰ স্থানীয় ভাষাত বুজি পোৱাৰ পিছত, মই এই অধ্যয়নত অংশগ্ৰহণ কৰিবলৈ ইচ্ছুক আৰু মোৰ সন্মতি দিওঁ।

তাৰিখ:
ঠিকনা আৰু পি.এইচ.
চহী:

ANNEXURE – IV

Population Demographic Data Format

Case Serial No.:	**Date:**

Name: ………………………………………………………………………………………

Age: ……………………………

Sex: M / F / Other: ………………………………………………..…………………

Address:
……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

Mobile number:
……………………………………………………………………………………………

E-mail address:
……………………………………………………………………………………………

Religion:
……………………………………………………………………………………………

Caste: ……………………………………………………………………………

Ethnic Group:

Kachari	**Mising**	**Bodo**	**Deori**

……………………………………………………………………………………………
………………………………………………………………………

ANNEXURE – V

ETHICAL CLEARENCE CERTIFICATE

Research and Ethics Committee
KLE VK INSTITUTE OF DENTAL SCIENCES
A Constituent Unit of KLE Academy of Higher Education & Research
Accredited 'A' Grade by NAAC   Placed in Category 'A' by MHRD (GoI)
Nehru Nagar, Belagavi - 590 010, Karnataka State
☎: 0831-2470362   Web: http://www.kledental-bgm.edu.in
FAX: 0831-2470640   E-mail:principal@kledental-bgm.edu.in

Sl. No. : 1632

CERTIFICATE

This is to Certify that the synopsis titled Evaluation of metric & non-metric dental features in ethnic groups of Assamese population for forensic profiling : A Cross-Sectional Study *Submitted by Dr.* **REG NO. IH0222001** *P. G. Student / Staff, Guided by* ______ *from Department of* Oral Pathology and Microbiology *has been critically evaluated by committee members and granted ethical clearance to conduct the above mentioned study*

Date : 26/3/25

Institutional Research and Ethical Committee KLE VKIDS NECRBHR, DHR® EC/NEW/INST/2025/KA/0599

Member Secretary	**Chairman**
Research and Ethical Committee	Research and Ethical Committee
KLEVK Institute of Dental Sciences	KLEVK Institute of Dental Sciences
Belagavi	Belagavi

ANNEXURE – VI

BIOSTATISTIC CLEARENCE CERTIFICATE

K L E
VISHWANATH KATTI
INSTITUTE OF DENTAL SCIENCES
A Constituent college of
K.L.E. Academy of Higher Education and Research
J.N.M.C. Campus, Nehru Nagar Belagavi -590010 Karnataka,
India.
Department of Oral & Maxillofacial Pathology and Oral Microbiology

BIOSTATISTICS CLEARANCE CERTIFICATE

This is to certify that the Biostatistics art of Dissertation/ Research work of **Dr.** REG NO. IH0222001 **Postgraduate student** under the guidance of **Professor& Principal, Department of Oral & Maxillofacial Pathology and Oral Microbiology** entitled **"**Evaluation of metric & non-metric dental features in ethnic groups of Assamese population for forensic profiling: A Cross-Sectional Study.**"** has been done under my guidance and considered satisfactory.

Place: Belagavi

Date: 19. 03. 2025

Name and signature of Biostatistician

Dr. S. B. Javali. Ph.D.
Professor In Statistics
Department of Community Medicine
USM KLE International Medical Programme,
BELAGAVI-590010.