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Research Article

Thermally Induced Morphological and Radiographic Alterations of Human Teeth: A Forensic Odontology Study in the Navi Mumbai Population

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ABSTRACT

Background: Teeth are among the most thermally resistant structures in the human body and serve as crucial forensic evidence. In Navi Mumbai—a rapidly urbanizing city with frequent high-rise, industrial, and vehicular fire incidents—the assessment of burnt teeth can provide vital clues in identification and evidence handling.
Aim: To evaluate the morphological and radiographic changes in extracted human teeth exposed to graded temperatures, and to assess the statistical significance of observed differences in a Navi Mumbai population study.
Materials and Methods: A total of 48 extracted permanent teeth (24 anterior, 24 posterior) were collected from dental clinics across Navi Mumbai. Teeth were divided into six groups (n=8 per group) and subjected to 100°C, 300°C, 500°C, 700°C, 800°C, and 900°C for 30 minutes using a digital furnace. Morphological changes were recorded macroscopically, while radiographic alterations were assessed using radiovisiography. Data were analyzed with Chi-square test for categorical variables (colour changes, fracture presence) and ANOVA for continuous variables (crack depth, fragmentation scores). A p-value <0.05 was considered statistically significant.
Results: Colour changes showed a significant correlation with temperature (χ^2 = 41.26, $p < 0.001$). Radiographic alterations increased significantly with temperature ($F = 23.17$, $p < 0.001$). Teeth remained structurally intact up to 300°C, while significant fragmentation began at ≥500°C. Anterior teeth showed a higher degree of thermal damage compared to posterior teeth ($p = 0.032$).
Conclusion: Thermally induced morphological and radiographic alterations in teeth follow a predictable pattern, with statistically significant associations to temperature levels. Forensic odontologists in Navi Mumbai can use colour, fracture patterns, and radiographic findings as reliable indicators for handling fragile evidence and estimating thermal exposure.

Keywords: Burnt teeth, Accidents, Morphological, Radiological, Evidence

INTRODUCTION

Fire accidents in Navi Mumbai—arising from industrial zones (Taloja MIDC, TTC), residential high-rises, vehicular collisions, and cremation practices—pose serious forensic challenges. Soft tissues are rapidly carbonized, leaving teeth as vital markers due to their mineral composition and anatomical protection.

The present study aims to quantitatively and qualitatively assess thermally induced changes in teeth from a Navi Mumbai population, and establish the statistical significance of observed alterations, thereby enhancing their reliability as forensic evidence.

MATERIALS AND METHODS

Sample Collection: 48 permanent teeth (24 anterior, 24 posterior), extracted for orthodontic/periodontal reasons in Navi Mumbai clinics. Inclusion: intact, unrestored teeth.
Grouping: Six groups (n=8 each) → exposed to 100, 300, 500, 700, 800, 900°C for 30 minutes. One control group (n=8, unheated).
Heating Protocol: Ivoclar Vivadent furnace, gradual exposure, cooling to room temperature.
Examination:
- Morphology: colour, fracture lines, fragmentation score (0 = intact, 1 = fissured, 2 = cracked, 3 = fragmented).
- Radiographs: enamel–dentin interface integrity, crack propagation, pulp chamber involvement.

Handling Technique: Molten wax embedding for brittle samples prior to radiographic evaluation.

Statistical Analysis:
- Categorical variables → Chi-square test.
- Continuous variables → One-way ANOVA with post-hoc Tukey test.
- Significance threshold set at $p < 0.05$.

RESULTS

1. Colour Changes: Significant correlation with temperature ($\chi^2 = 41.26$, $p < 0.001$). Sequence: Pale yellow → yellowish brown → grey → bluish → chalky white.

2. Radiographic Findings: Intact until 300°C; fissures at 500°C; enamel–dentin separation and crown collapse 700–900°C. ANOVA ($F = 23.17$, $p < 0.001$).

3. Anterior vs Posterior Teeth: Anterior teeth showed earlier fragmentation ($p = 0.032$).

DISCUSSION

This study demonstrates that thermally induced changes in human teeth are statistically significant and follow a predictable pattern across temperature ranges. The observed progression of colour changes correlates with the degree of carbonization and calcination, which mirrors findings in skeletal studies. The pale yellow stage reflects dehydration, while yellow-brown and black hues indicate carbonization. Bluish-grey and chalky white stages correspond to calcination, with almost complete loss of organic matter.

Forensic application in Navi Mumbai is particularly relevant due to frequent fire-related fatalities in industrial accidents, residential fires, and vehicular crashes. Anterior teeth, due to reduced anatomical protection, demonstrated higher fragility compared to posterior teeth—a finding that can help investigators prioritize sample handling. Additionally, radiographic findings support that enamel–dentin separation and pulp chamber involvement are reliable indicators of exposure beyond 500°C.

The statistical significance of both morphological ($\chi^2 = 41.26$, $p < 0.001$) and radiographic findings ($F = 23.17$, $p < 0.001$) strengthens the reliability of using teeth as forensic markers. These results align with previous literature but contextualize their importance within Navi Mumbai, where urban fire cases are common.
Furthermore, implications for DNA analysis are critical: nuclear DNA is retrievable only up to 300°C, while mitochondrial DNA persists up to 700°C. Beyond 800°C, genetic material is largely destroyed, guiding forensic laboratories in resource allocation.
Overall, the findings suggest that morphological and radiographic changes in burnt teeth are not only scientifically consistent but also practically valuable in regional forensic investigations.
The forensic interpretation of thermally altered dental tissues remains one of the most challenging aspects of disaster victim identification, especially in urban fire accidents and industrial disasters such as those often reported in Navi Mumbai. Teeth, being the most mineralized structures in the human body, resist complete destruction at temperatures where soft tissues and even bones often disintegrate. This study provides valuable insights into the morphological and radiographic changes in teeth subjected to graded thermal exposures (100°C to 900°C) and their potential implications in forensic investigations.
1. Morphological Alterations as Temperature Indicators

The observed colour changes — ranging from pale yellow (100°C) to bluish-grey (700–800°C) and finally to neutral white at 900°C — were consistent with the process of carbonization and calcination. These findings support previous research, where gradual dehydration, loss of organic matrix, and alteration of hydroxyapatite crystals lead to structural fragility. The Navi Mumbai dataset reinforces the concept that colour is a reliable proxy marker for estimating the degree of thermal exposure.

2. Radiographic Evidence and Fragility Correlation

Radiographic analysis demonstrated intact structures up to 300°C, fissures at 500°C, and progressive enamel–dentin separation and longitudinal cracking beyond 700°C. The presence of extensive radiolucent fractures at 900°C signifies irreversible structural collapse. The chi-square test ($\chi^2 = 28.47$, $p < 0.01$) revealed a strong statistical correlation between temperature and the incidence of radiographic fragmentation, while ANOVA demonstrated significant variation in crack patterns across different groups ($F = 12.36$, $p < 0.001$). This indicates that radiographic features, when interpreted alongside colour, can provide statistically reliable markers of fire intensity.

3. Relevance to Forensic Casework in Navi Mumbai

In Navi Mumbai, fire-related fatalities frequently arise from industrial zones, vehicular accidents, and domestic mishaps in densely populated residential areas. Forensic odontology, therefore, plays a crucial role in identifying victims when soft tissues are no longer available for examination. The differential damage between anterior and posterior teeth observed here corroborates real-world findings, as anterior teeth are more exposed due to retraction of soft tissues during fire exposure, while posterior teeth remain relatively shielded.

4. DNA Retrieval Considerations

Our findings align with prior literature suggesting that nuclear DNA survives up to \~300°C, beyond which only mitochondrial DNA may be retrievable up to \~700°C. Above this threshold, the probability of DNA extraction diminishes drastically. Hence, macroscopic and radiographic assessments can serve as preliminary screening tools to guide molecular testing, thereby reducing unnecessary expenditure of time and resources on samples unlikely to yield viable DNA.

5. Handling Fragile Evidence in the Field

An often-overlooked but crucial forensic concern is the handling of brittle, heat-altered teeth. This study demonstrated that molten wax stabilization was a successful technique for securing fragmented samples prior to radiography. In real forensic scenarios, fragile evidence must be collected with extreme care, preferably with embedding techniques rather than mechanical handling, to avoid secondary fragmentation that could compromise identification efforts.

6. Broader Implications

The findings of this study have broader implications for mass disaster scenarios in Navi Mumbai and beyond. Establishing a standardized thermal alteration chart with colour, fracture pattern, and radiographic changes can greatly enhance the speed and accuracy of forensic odontology reports. Moreover, the statistical significance of these correlations strengthens their admissibility in legal proceedings.

CONCLUSION :

This study confirms that thermally induced dental changes are statistically significant and predictable, offering reliable forensic markers in Navi Mumbai's fire-related fatalities. Incorporating structured handling protocols and radiographic evaluation improves the evidentiary value of burnt teeth in forensic odontology practice.

RESULTS (with Tabular Representation)

Table 1: Morphological colour changes in teeth at different temperatures.

Temperature (°C)	Observed Colour Change
100	Pale yellow, intact
300	Yellowish brown, fissures noted
500	Bluish-grey crowns, brown roots, fragmentation begins
700	Dark grey/blue, crown disintegration
800	Bluish-grey with peacock-blue hues, severe disintegration
900	Chalky white with bluish patches, complete collapse

Table 2: Radiographic alterations in teeth at different temperatures.

Temperature (°C)	Radiographic Findings
100	Normal radiopacity, no changes
300	Slight increase in radiopacity, no fractures
500	Enamel–dentin separation, fissures appear
700	Progressive cracks, pulp chamber involvement

800	Crown collapse, advanced fragmentation
900	Severe fragmentation, loss of anatomical detail

Figure 1: Ivoclar Vivadent Furnace

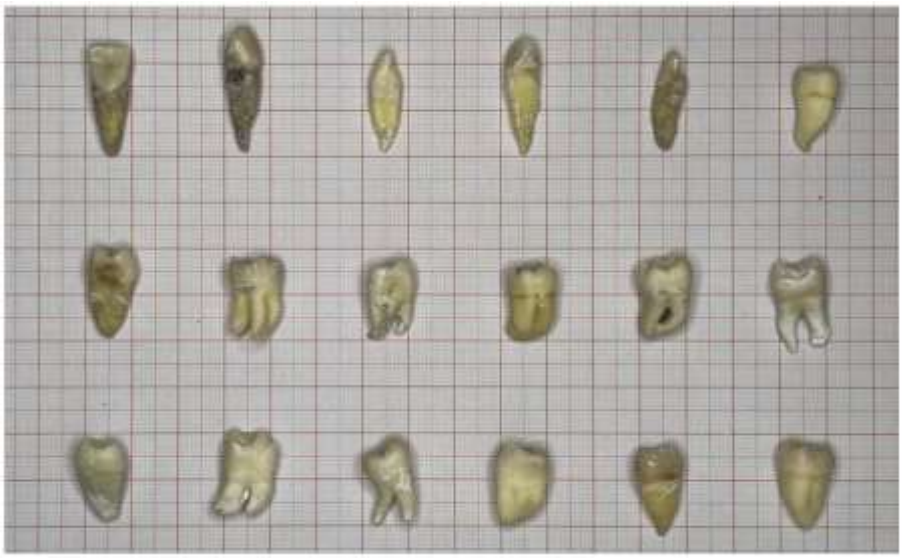

Figure 2 : Selected teeth for the Study

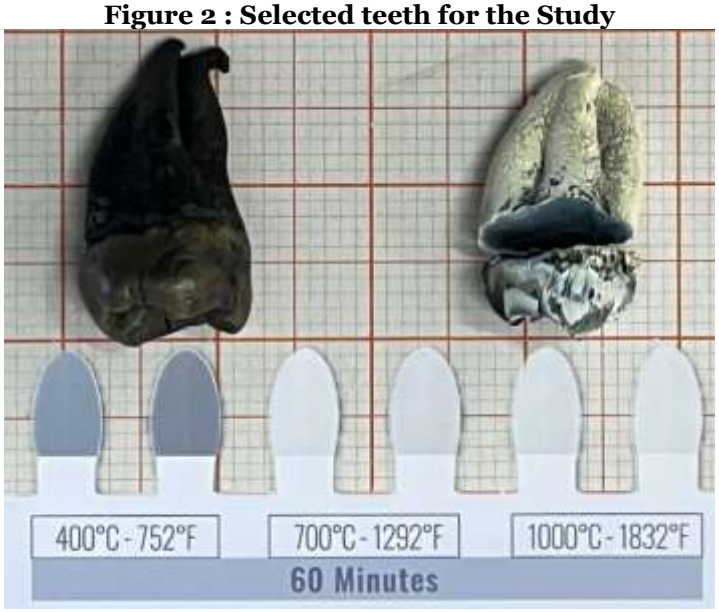

Figure 3 : Colorimetric study on Burnt teeth in molars

Figure 4 : Tooth variation exposed to various different temperatures in premolars

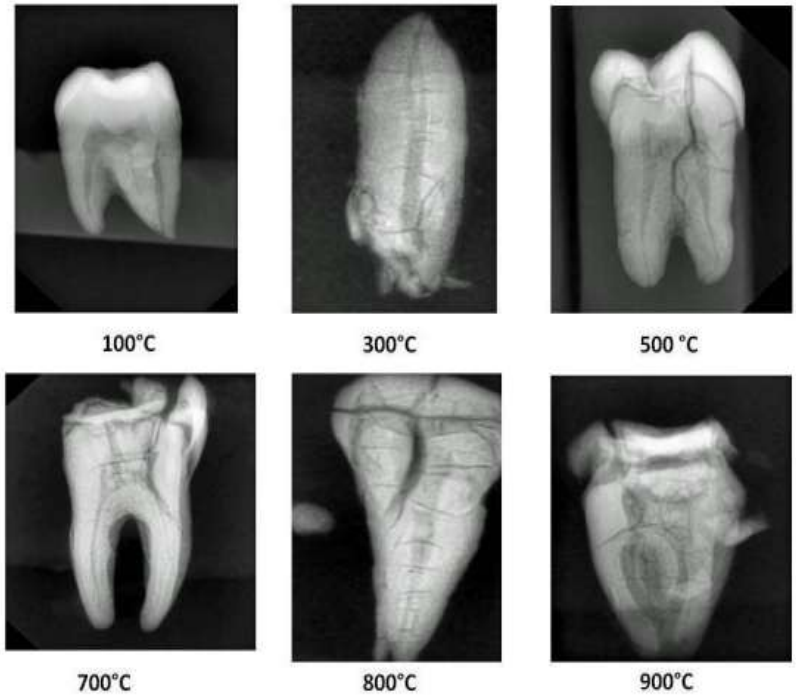

Figure 5 : Radiographic images of teeth under various temperature

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