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Comparative Evaluation of the Resistance of Various Denture Labelling Systems to Simulated Assaults: An in Vitro Study

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Denture labelling, forensic identification, forensic dentistry, prosthetic identification

ABSTRACT:
Background: Denture marking has been strongly advocated and recommended by several forensic organizations. Prosthodontists can play a pivotal role in the identification of the geriatric population by incorporating denture marking as a routine clinical practice.
Aim: The aim of the study was to evaluate the visibility, durability and forensic reliability of various denture labelling methods to different simulated assaults.
Study Setting and Design: In vitro study.
Materials and method : A total number of 280 blocks of heat cure polymethylmethacrylate resin were prepared. Seven different labelling methods (engraving method, emboss method, marker pen, barcode label and three different metal strips—aluminum strip labelling, tin strip labelling and copper strip labelling) were employed and subjected to four different assaults: acid immersion, alkali immersion, water immersion and fire. The data obtained was statistically analysed and subjected for comparative evaluation.
Statistical analysis used: Descriptive statistics.
Results: Surface markings such as engraving and embossing were significantly less effective in withstanding thermal, chemical and water-based assaults ($p<0.05$). Metallic inclusion labels, especially copper, demonstrated statistically significant resilience across all assaults ($p<0.05$).
Conclusion: Surface labels are unreliable for postmortem identification. Metallic inclusion labels, particularly those made of copper and similar durable alloys, were reliable and hence can be adopted as the standard for denture labelling in forensic dentistry.

Introduction

The integration of dentistry and forensic science has significantly enhanced human identification, particularly in situations where conventional methods such as fingerprinting or DNA analysis are not feasible.[1,2] Owing to their resilience, teeth often provide critical evidence in forensic investigations. However, the identification of edentulous individuals—those without natural teeth—presents specific challenges due to the absence of distinguishing dental features.[3] This has led to the adoption of denture labelling systems, which incorporate unique identifiers into dental prostheses to aid in identification during mass disasters, accidents or criminal cases.[4]

Denture marking is a recognized method for identifying both dentures and individuals, particularly in geriatric institutions or during post-mortem examinations following war, crimes, civil unrest, and natural or mass disasters. Prosthodontists play a crucial role in forensic dentistry, as they are responsible for fabricating various prostheses that can aid significantly in the identification process.[5]

Labelling techniques are generally divided into surface and inclusion methods. Surface labels, such as engraving, embossing, or specialized ink markings, are cost-effective and simple to apply but tend to fail under harsh conditions like fire or chemical exposure.[6] Inclusion methods embed

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identifiers, such as metal strips, microchips, or barcodes, into the denture base. These techniques offer superior durability against thermal, chemical, and mechanical challenges.[7] Metallic inclusion labels, in particular, exhibit excellent resistance to high temperatures and corrosive environments, making them reliable for forensic use.[8,9]

Despite these advancements, most research has focused on standard forensic scenarios. Emerging cases involving extreme environmental exposure—such as fires, chemical assaults, or prolonged decomposition—highlight the limitations of current labelling methods.[10,11] Moreover, the increasing number of elderly individuals who are edentulous underscores the need for proactive identification strategies.[4,12] Moving forward, there is a pressing need to refine existing methods and develop new, more resilient materials and technologies that can withstand severe conditions while ensuring timely and accurate identification.[13,14]

Hence the present study was conducted with the aim to examine the visibility, durability and forensic reliability of various denture labelling methods under various simulated conditions of postmortem assaults. The null hypothesis of the study was that there was no difference in visibility, durability and forensic reliability of various denture labelling methods under various simulated conditions of postmortem assaults.

Materials and Method

The present study was conducted in department of Prosthodontics. Using the formula $n = (Z_{\alpha/2}+Z_{\beta})^2 * (p_1(1-p_1)+p_2(1-p_2)) / (p_1-p_2)^2$ where $Z_{\alpha/2}$ was the critical value of the normal distribution at $\alpha/2$, Z_{β} was the critical value of the normal distribution at β, p1 as 92.5% and p2 as 85 % (calculated from pilot study), the sample size was calculated as 280.

A total number of 280 rectangular blocks were fabricated using heat-polymerised polymethyl methacrylate resin (DPI™), a commonly used material in denture construction. These blocks were designed to simulate the posterior flange area of a denture base. Each block measured 5 cm in length, 5 cm in width, and 0.5 cm in thickness, providing a standardized surface for evaluating various denture labelling techniques.

A total of seven different labelling methods, readily available and frequently used in prosthodontics, were selected for assessment. These methods were broadly categorized into two types: surface labels and inclusion labels. Surface labelling methods included engraving, embossing, and permanent marking techniques, all of which are manually applied and externally visible. The inclusion labels consisted of a barcode and three different metal strips—aluminum, tin, and copper—incorporated within the resin during fabrication. These techniques were chosen based on their accessibility, ease of application, and relevance to forensic identification in edentulous individuals.

<u>Surface labels</u>

1. Engraving (figure 1): A round head dental bur was used to etch information “9801” in the acrylic block.
2. Embossing (figure 2): The information “9801” was engraved into the stone mold used for denture flasking in mirror image so that it appeared as elevated symbols on the acrylic block.
3. Marking (figure 3): The information “9801” was written with a spirit-based marker pen in the acrylic block.’


Figure 1: Engraving Method of Denture Labelling


Figure 2: Embossing Method of Denture Labelling


Figure 3: Marking Method of Denture Labelling

<u>Inclusion labels</u>

Two millimeters deep troughs were made in the acrylic block to accommodate the inclusion labels (figure 4). The

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grooves were 2 mm larger than the length and width of the labels for its easy placement.

1. Barcode Sticker: A barcode sticker routinely used in dental setups for patient discretion and misconfusion was used. It was covered by cello tape on both the sides, cut of size, and placed in the acrylic block.
2. Aluminium metal strip: The aluminium metal strip commonly found in an was written upon “9801” in mirror image so that it appeared as embossed letters on the other side. It was cut of size and placed in the acrylic block.
3. Tin metal strip: Commonly found tin metal sheet was used and “9801” was stamped onto the metal strip with the help of micromotor and a bur and placed in the acrylic block.
4. Copper metal strip: A copper palette was stamped “9801” and placed in the acrylic block.

Figure 4: Inclusion Method of Denture Labelling

After placing the labels in their grooves, they were covered by transparent heat-cured acrylic resin and cured under heat for 1 hour. The blocks were then trimmed and polished.

Each block fabricated was subjected to:

1. Assault I: Exposed to naked flame to test the resistance of denture labels to high temperatures simulating fire exposure.
2. Assault II: Immersion in concentrated sulfuric acid (concentration 98.9%) for 24 hours. This was conducted to test the durability of labels against corrosive substances.
3. Assault III: Immersion in water for 24 hours to analyze the resilience of labels when exposed to water submersion.
4. Assault IV: Immersion in concentrated sodium hydroxide for 24 hours to analyze the resilience of labels when exposed to alkaline submersion.

The data collected was entered in MS excel and analyzed using SPSS 16.0 for windows (SPSS Inc, Chicago, IL, USA, 2001). The normality of data was tested by Shapiro wilks test. The descriptive statistics, including the frequency, % frequency, was calculated for all measurements. The significance of association between types of labels and tests were tested by Pearson’ Chi square tests. The level of significance (p value) and confidence interval were 5% and 95 % respectively.

Results

Based on the results of the study, it was found that there was significant difference in visibility and durability of surface and inclusion labels ($p<0.05$)

When denture blocks were subjected to water immersion test, the surface labels (engraving, embossing, marker pen) showed no change and were readable. The metal strips and barcode remained unaffected, providing clear and legible information post-immersion.

When denture blocks were subjected to alkaline immersion test, the surface labels (engraving, embossing, marker pen) showed no change and were readable. Likewise metal strips and barcode remained unaffected, providing clear and legible information post-immersion.

When denture blocks were subjected to thermal exposure test, the surface labels inscriptions were completely erased or burned beyond recognition. Inclusion labels, particularly metal strips showed partial legibility but suffered significant discoloration. Barcode stickers were severely damaged or completely destroyed (figure 5).

Figure 5: Inclusion and Surface Label after Assault IV

On application of Pearson’s Chi square test, a significant association ($p=0.031$) was found between types of denture labels and various simulated assaults. The metallic labels i.e. tin, aluminium and copper were significantly more reliable($p<0.05$) than other methods of denture labelling (table 1, graph1).

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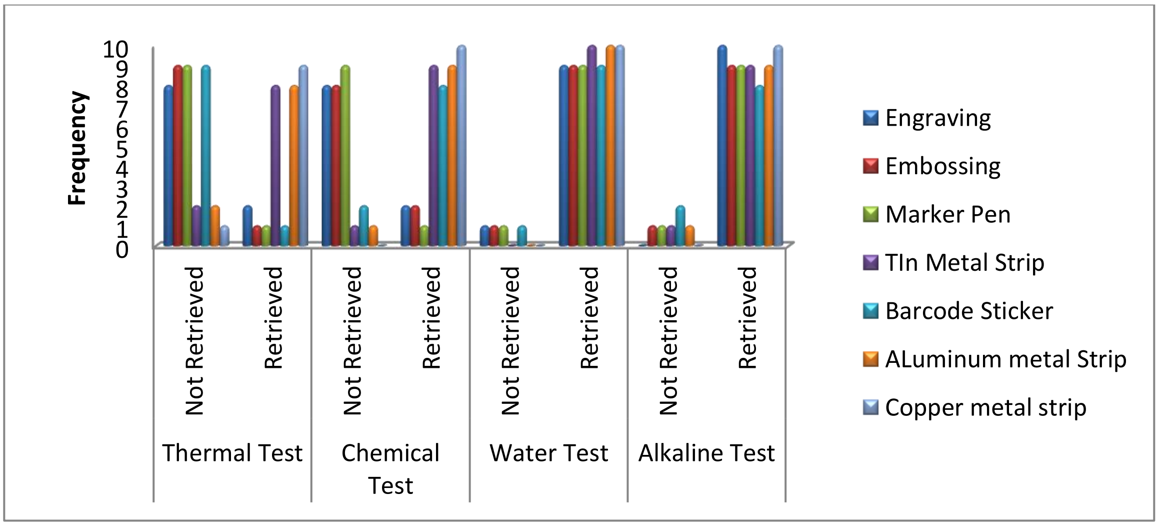
Table 1: Comparison of different assaults on denture labelling system

Labelling Method	Thermal Test		Chemical Test		Water Test		Alkaline Test		Final Status
	Not Retrieved	Retrieved	Not Retrieved	Retrieved	Not Retrieved	Retrieved	Not Retrieved	Retrieved	
Engraving	8	2	8	2	1	9	0	10	Not Reliable
Embossing	9	1	8	2	1	9	1	9	Not Reliable
Marker Pen	9	1	9	1	1	9	1	9	Not Reliable
Tin Metal Strip	2	8	1	9	0	10	1	9	Highly Reliable
Barcode Sticker	9	1	2	8	1	9	2	8	Moderately Reliable
Aluminium metal Strip	2	8	1	9	0	10	1	9	Highly Reliable
Copper metal strip	1	9	0	10	0	10	0	10	Highly Reliable
Pearson's Chi square = 30.67, p=0.031									



Graph 1: Effect of simulated assaults on different denture labelling system

Discussion

Denture identification plays an essential role in forensic investigations, particularly in scenarios involving mass disasters, unclaimed bodies, or edentulous individuals. The success of denture labelling depends on the ability of the identification marker to withstand extreme physical and chemical conditions without compromising legibility or retrievability.

The null hypothesis of the study that there was no difference in visibility, durability and forensic reliability of various denture labelling methods under various simulated conditions of postmortem assaults was rejected. A significant difference was found in visibility, durability and forensic reliability of surface and inclusion labels ($p<0.05$).

In the present study, surface labelling techniques such as engraving, embossing, and marker pen proved unreliable after thermal and chemical exposure. These findings are consistent with prior literature that emphasizes the vulnerability of surface markings to degradation postmortem.[1–3]

In contrast, inclusion methods using metal strips—specifically tin, aluminum and copper demonstrated high reliability across all test parameters, including thermal, chemical, water, and alkaline challenges. These results support previous findings that owing to durability, biocompatibility, affordability and ease of incorporation into denture bases, embedded identifiers are superior choice for

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forensic purposes. Unlike surface labels that fade or detach, metallic labels remain securely embedded, ensuring long-term traceability and suitability for long-term forensic identification.[4–7] The barcode label showed moderate reliability, performing poorly under thermal stress, confirming concerns raised by Millet and Jeannin regarding the limitations of digital markers in high-temperature environments.[6]

This research introduces a novel approach by simulating an expanded range of postmortem conditions rarely addressed in earlier studies. Beyond standard protocols, the study proposes advanced testing such as higher-temperature incineration, simulating real-world crematorium conditions (>1200°C), and prolonged exposure to aggressive acids and alkalis to better reflect complex forensic recovery scenarios.[8–10] It also evaluates hybrid labelling systems combining metallic and non-metallic elements, aiming to improve durability and visibility.

The practical need for this research is underscored by the growing number of cases requiring forensic dental identification and the inadequacy of current labelling systems under extreme conditions. By identifying robust materials and techniques, the study enhances the forensic relevance of denture labelling. Additionally, clinical feasibility is considered, evaluating whether advanced labelling can be integrated into routine practice without compromising aesthetics or cost. Importantly, these findings can inform the development of globally standardized guidelines, aligning with ethical and legal obligations in forensic and prosthodontic fields.[14–16] By bridging the gap between forensic demands and clinical application, the present research proposes a more resilient and practical approach to denture labelling to ensure reliable identification of vulnerable populations during disaster victim identification or medico-legal investigations.

Future studies should investigate the integration of advanced digital technologies, such as RFID and microchips, to further enhance identification accuracy and utility in disaster victim identification and other forensic scenarios.

Conclusion

Within the limitations of the study, it was concluded that metallic inclusion labels, particularly those made of copper and similar durable alloys, were significantly more reliable ($p<0.05$) than surface markings when subjected to various simulated assaults. Hence they can be considered superior over surface denture labelling techniques in forensic dentistry for postmortem identification.

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Conflicts of Interest

There are no conflicts of interest.

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