The Effects of Household Corrosive Substances on Restored and Non-Restored Teeth

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Introduction

In unique forensic contexts, human remains can be deliberately and permanently altered in order to hinder their identification and prevent discovery. One process that can potentially obscure the identification of an individual is through exposure to corrosive chemicals, which may cause regions of the body to breakdown. Easily obtained household chemicals have been documented in forensic cases to liquefy bodies, thereby preventing discovery and identification[1-4]. Even though researchers have acknowledged that the use of common household corrosive substances can dramatically alter a body, little research has exposed human remains to various corrosive substances over a long duration in order to qualitatively and quantitatively explore how such exposure impacts skeletal structures or dentition. Most research has identified how corrosive chemicals affect the body within very circumscribed timeframes[1-3]. Other research has focused on how human soft tissue, bone, hair, skin, nails and teeth are affected by acid exposure[2]. While these studies establish important baseline knowledge for understanding how specific substances and short-duration exposure can affect soft tissue, bone and dentition, most studies exposed the samples for a minimal time period and neglected to explore how subsequent changes would impact positive identifications[1-3]. Specifically, a gap in the literature exists regarding the chemical effects of household corrosive acids at different concentrations and durations on restored and non-restored dentition. The present research seeks to expand previous studies by exposing restored and non-restored human premolars and molars to hydrochloric and sulfuric acids at different concentrations over an extended time period of 2 – 264 hours in order to determine how acidic alterations impact radiographic imaging used in the positive identification process.

TABLE 1 – *Household acidic products used and associated concentrations.*

Product Name	Acid	Concentration
Clorox® Bleach Cleaner	Hydrochloric	8.25%
The Works® Toilet Bowl Cleaner	Hydrochloric	20%
Rooto® Drain Opener	Sulfuric	93.2%
Watchdog® Battery Acid	Sulfuric	51%
Biz® Detergent	N/A	N/A

TABLE 2 – *Ordinal scoring scale used to document acidic changes.*

Score	Observed Changes to Enamel, Dentin and/or Restoration
0	No changes, enamel intact. No visible dentin. Restoration intact.
1	Loss of small amounts of enamel. Still no dentin exposure. Restoration may begin to deteriorate.
2	More enamel lost. Small areas of dentin exposed. Restorations begin to show visible change/deterioration.
3	Minimal enamel present. Moderate areas of dentin exposed. Restoration has separated from crown.
4	No enamel present. Dentin complexly exposed. Complete separation of restoration from tooth.
5	Complete or near complete dissolution of the tooth and restoration.

Materials and Methods

This study utilizes **105 adult human premolars (n=46) and molars (n=59)** consisting of restorations composed of **silver amalgam** (n=62), **porcelain-fused-to-metal** restorations (n=25), and teeth with **no restorative material** (n=18). All samples were collected from the Body Donation program cadavers at Boston University's Division of Graduate Medical Sciences. The premolars used for this study consist of 16 silver amalgam samples, 20 porcelain-fused-to-metal samples, and 10 non-restored samples per solution. The molars used for this study consist of 46 silver amalgam samples, five porcelain-fused-to-metal samples and eight non-restored samples per solution. The household corrosive chemical agents consist of **hydrochloric acid** and **sulfuric acid**, along with **one base** as a control (Table 1). Teeth were placed into **20 mL** of each solution and were removed from the solutions throughout the experimental process after **1, 2, 4, 8, 24, 72, 120 and 264 hours**. Documentation included mass, mesio-distal (MD) and buco-lingual (BL) crown measurements, and photography (Fig. 1). The teeth were radiographed before and after exposure to the various household products to mimic antemortem and postmortem radiographs (Fig. 2). Additionally, an ordinal scoring system was developed to assess the visual changes after exposure to the acids (Table 2). One-way analyses of variance (ANOVAs) and logistic regressions in SPSS tested if significant changes occurred and if the pre- and post-exposure radiographs could be matched.

Results

The results indicate that 86 (82%) of the teeth were positively identified by radiographs after exposure to the acids. The Works® Solution (20% hydrochloric) was the most destructive of the five household products, causing deterioration to the enamel, dentin and pulp. Some silver amalgam and non-restored samples suffered liquefaction. The silver amalgam restorations split from the teeth during liquefaction, but remained mostly intact. Porcelain-fused-to-metal restorations were not affected by The Works® Solution. However, only 28% of the total sample exposed to The Works® Solution (n=6) were positively identified by radiographs (Fig. 2). Watchdog® Battery Acid (51% sulfuric) was the next most destructive product, which caused deterioration to parts of the enamel and some of the dentin (Fig. 1). A total of 15 teeth (75%) were positively identified after exposure to the battery acid. Exposure to Clorox® Bleach Cleaner (8.25% hydrochloric) and Rooto® Drain Opener (93.2% sulfuric) resulted in minimal damage to the teeth, with 100% of the teeth positively matched by radiographs after exposure. Only the outermost enamel was affected by these two solutions. Exposure to Biz® Detergent, which is commonly used in maceration[5], had no effect on the teeth, with 100% positively identified by radiographs.

The mass and MD/BL measurements all decreased significantly for the teeth that were exposed to hydrochloric and sulfuric products. The mass, MD/BL measurements slightly decreased in size after exposure to Clorox® and Rooto®. No significant changes in mass, BL/MD diameters were seen in dentition exposed to Biz® Detergent. ANOVAs including all variables (mass, BL/MD and ordinal scoring) indicated that mass, MD diameter and the ordinal scores were all statistically affected when exposed to Clorox® Bleach Cleaner, Rooto® Drain Opener and Watchdog® Battery Acid ($p < 0.003 – 0.001$). Further, exposure to The Works® Solution resulted in statistically significant effects in all variables for silver amalgam and non-restored samples ($p < 0.001 – 0.000$). Logistic regressions identified that acid type and acid concentration had a statistically significant affect ($p < 0.02 – 0.015$) while the restoration type (porcelain-fused-to-metal versus silver amalgam) did not ($p > 0.5 – 0.90$).

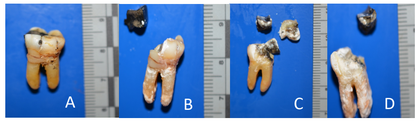

FIG. 1 – *Example of Watchdog® Battery Acid effects on silver amalgam samples. A) Before exposure, score=0; B) After 2-hours exposure, score=3 (note separation of restoration); C) After 72-hours exposure, score=3; D) After 120-hours exposure, score=3 (note chalky appearance).*

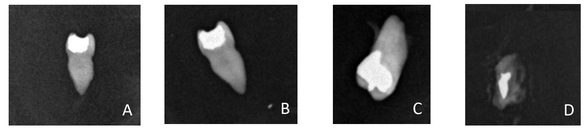

FIG. 2 – *Example radiographs of silver amalgam samples before and after exposure to household products. A) Premolar before exposure to Clorox® Bleach; B) Premolar after exposure to Clorox® Bleach; C) Molar before exposure to The Works® Solution; D) Molar after exposure to The Works® Solution.*

Discussion and Conclusions

The present study demonstrates how common household acidic products affect dentition after 2 – 264 hours of exposure. Products that contain hydrochloric acid (The Works® Solution and Clorox® Bleach Cleaner) and sulfuric acid (Watchdog® Battery Acid) have the ability to eliminate dental morphological structures, unique features or trauma that could lead to a potential identification (Figs. 1 and 2). In particular, hydrochloric acid aggressively attacks the enamel quickly and eradicates the hydroxyapatite mineralized component within the first two hours of exposure. Teeth are known to be the hardest, most durable structures in the body, but can be destroyed when exposed to certain acidic products. These results suggest that with enough corrosive product and a long exposure time, it may be possible to completely dissolve a human body; however, more research is warranted.

Near complete or complete liquefaction in high concentrations of hydrochloric acid solution of non-restored and silver amalgam samples, minus the silver restorations, occurred within 120 hours. However, the dentition with porcelain-fused-to-metal restorations in the same solution/concentrations did not liquefy, which suggests that this type of restoration hinders the deleterious effects of hydrochloric acid on teeth. Based on these results, along with previous research[1-4], it may be possible to completely liquefy a human body in a relatively short amount of time and hinder identification. However, porcelain-fused-to-metal restorations and associated dental structures, along with silver amalgam restorations, may remain even if the teeth do not and could therefore assist with identification. Further research should explore how higher concentrations of corrosive material impact unaltered and restored dentition and associated skeletal structures. In particular, further research should include whole body regions and intact human remains, along with dentition (unaltered and restored) to better understand how acid attacks the soft tissue, bone and dentition as a whole.

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