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Abstract

The study aimed to compare the dentine wear of primary and permanent human and bovine teeth because of erosion/abrasion and evaluate if bovine dentine is an appropriate substitute for human dentine in further erosion/abrasions tests. Dentine samples from deciduous molars and human third molars as well as from calves' and cattle's lower incisors were prepared and baseline surface profiles were recorded. Each day all samples were demineralized in 1% citric acid, tooth brushed with 100 brushing strokes with toothpaste slurry and stored in artificial saliva for the rest of the day. This cycle was run for 20 days. Afterwards, new surface profiles were recorded and dentine wear was calculated by a customized computer program. Dentine wear because of erosion/abrasion was not statistically, significantly different for human third molars and cattle's lower incisors ($P = 0.7002$). The dentine wear because of erosion/abrasion of deciduous molars and calves' lower incisors was significantly different ($P < 0.0000$). No statistically significant difference in the dentine wear of human third molars and cattle's lower incisors was observed, so that the use of cattle's lower incisors as substitute for adult human teeth for further investigations in erosion/abrasion studies could be accepted.

Is bovine dentine an appropriate substitute for human dentine in erosion/abrasion tests?

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ABSTRACT

Objective: The study aimed to compare the dentine wear of primary and permanent human and bovine teeth due to erosion/abrasion and evaluate if bovine dentine is an appropriate substitute for human dentine in further erosion/abrasions tests.

Methods: Dentine samples from deciduous molars and human third molars as well as from calves and cattle`s lower incisors were prepared and baseline surface profiles were recorded. Each day all samples were demineralised in 1% citric acid, tooth brushed with 100 brushing strokes with toothpaste slurry and stored in artificial saliva for the rest of the day. This cycle was run for twenty days. Afterwards, new surface profiles were recorded and dentine wear was calculated by a customised computer program.

Results: Dentine wear due to erosion/abrasion was not statistically significantly different for human third molars and cattle`s lower incisors ($p=0.7002$). The dentine wear due to erosion/abrasion of deciduous molars and calves lower incisors was significantly different ($p<0.0000$).

Conclusion: No statistically significant difference in the dentine wear of human third molars and cattle`s lower incisors was observed, so that the use of cattle`s lower incisors as substitute for adult human teeth for further investigations in erosion/abrasion studies could be accepted.

KEYWORDS

dentine wear

erosion/abrasion

surface profilometry

human

bovine

Introduction

An increase in reported cases of dental erosions in younger age groups has been seen in the literature.[1] Since tooth wear is increased when the softened tooth surface is mechanically stressed[2,3], tooth wear due the combination of erosion and abrasion has been the topic of several studies. When dentine is exposed to an acid, at first a release of minerals from the peritubular/intertubular dentine junction occurs. Later, the peritubular dentine is lost and the dentine tubuli are widened.[4] Finally, a superficial layer of demineralised collagenous matrix is detectable.[5] It is conceivable that this superficial layer of collagenous matrix might protect the remaining demineralised dentine against mechanical effects like toothbrush abrasion.[6]

Many of the studies investigating tooth wear due to erosion/abrasion use bovine teeth as a substitute for human dental hard tissues.[7-9]

Bovine lower incisors are used for two main reasons. Firstly, it is easier to obtain a sufficient number of sound bovine teeth than human teeth. Secondly, the bigger surface area of bovine lower incisors allows preparation of more than one specimen from the same tooth. Thus, control specimens can be obtained from the same surface. Bovine teeth, derived from animals of similar genetic lineage and dietary environment, might show higher homogeneity of mineral composition than different human teeth, which are collected from various donators with diverse dietary or fluoride supplementation.

There are only a few investigations that have evaluated the possibility of substituting bovine teeth for human hard tissues.[10-12] Some of those studies focused on demineralization (erosion) of enamel and dentine.[11] Other investigations compared various mechanical properties, like microhardness or tensile strength[10,12] or the number and diameter of the dentine tubules.[13] Other studies were performed to examine, whether bovine teeth could be used as substitutes for human teeth, when

testing different bonding methods or bonding substrates.[14] Also the permeability characteristics of human and bovine dentine were compared.[15]

Despite these comparative studies, there is no information, whether tooth wear due to erosion/abrasion of bovine and human teeth is similar or not. A typical erosion/abrasion occurs, when an acidic challenge is followed by a mechanical stress, such as toothbrushing. Therefore, the aim of the present study was to compare wear of dentine due to erosion/abrasion of adult and young human and bovine teeth under standardized conditions, using toothbrushing as the abrasive influence.

The hypothesis of this study was that the tooth wear due to erosion/abrasion of human and bovine teeth is equal within the primary and permanent teeth of the different species.

Materials and methods

In the study, 144 samples were prepared from calves (age under 12 month, n=36) and cattles (age over 12 month, n=36) lower incisors as well from retained human third molars (n=36) and human deciduous molars (n=36). The crowns were sectioned from the roots at the cementum-enamel junction and the pulpal tissues were removed from the crowns with endodontic files.

The crowns were embedded in acrylic resin (Palavit G, Kulzer Wehrheim, Germany) in cylindric sample moulds made of steel with an inner diameter of 25 mm. The buccal surfaces of the crowns were directed to the bottom of the sample mould.

The samples where removed from the moulds and the buccal surface of the samples were ground with water-cooled carborundum discs (800, 1000, 1200, 2400 and 4000 grit; Water Proof Silicon Carbide Paper, Struers, Erkrath, Germany) until a smooth,

flat area of dentine was exposed. After polishing, new acrylic resin was put on the bottom of the samples for aligning the polished surface parallel to the bottom surface. On the polished dentine surface a window of 1.5mm x 10.0mm was marked with indents using a scalpel. The dentine surrounding the window was covered with tape (Tesa, Beiersdorf, Hamburg, Germany). Finally, the samples from the respective tooth type were divided in three treatment groups (A-C). Samples A were submitted to erosion only, samples B to erosion/abrasion and samples C to abrasion only.
From all samples three baseline profiles were recorded with a stylus profilometer (Perthometer, Mahr, Göttingen. Germany). Profiles were recorded over the whole polished dentine surface. The areas surrounding the window were used as reference areas.

The study ran for 20 days and each day the following protocol was performed:

1. Demineralization of samples A and B in 1% citric acid for 1 min (pH 2.3; 23°C). Each sample was stored in 20 ml of the solution
2. Rinsing the samples with distilled water
3. Remineralization of the samples in artificial saliva for 15 min. at room temperature. Each sample was stored in 20 ml of artificial saliva
4. Toothbrushing abrasion of the samples B and C for 1 min.
5. Rinsing of the sample with distilled water
6. Remineralization of the whole sample in artificial saliva for the rest of the day at room temperature

The toothbrushing abrasion was performed in an automated brushing machine (VDD Elektronic, Freiburg, Germany) for 1 min. The brushing frequency was amounted to 100 brushing strokes per minute and the brushing load was adjusted to 3 N.[2,16] The

toothbrush heads had a medium bristle stiffness (elmex39, Gaba, Münchenstein, Switzerland). During the toothbrushing the samples were totally covered with toothpaste slurry composed of 100 g toothpaste (elmex, Gaba, Münchenstein, Switzerland) and 300 g artificial saliva. For each cycle new toothpaste slurry was used.

The artificial saliva for the remineralization and the preparation of the toothpaste slurry was mixed according to the following formula (see Table 1).[17]

After finishing the 20-day-cycle, three new surface profiles of each sample were recorded and the tooth wear was calculated by comparing the post-treatment profiles with the baseline profiles with a custom-made software. Exact reposition of the samples was ensured by a special jig.

The data were proved for normal distribution (Kolmogoroff–Smirnoff test) and two-sided t-tests were carried out for determination if the dentine wear due to erosion/abrasion is equal among the different tooth substrates for the respective treatment regimes. Significance level was set to $p \leq 0.05$ and the p-values were adjusted by Bonferroni-Holm correction.

Results

The results are shown in figure 1.

As shown in Fig. 1, dentine wear caused by abrasion only (treatment C) was not statistically significantly different in all tooth groups.

There was a significantly higher substance loss due to erosion/abrasion (treatment B) than due to erosion (treatment A) or abrasion (treatment C) for all kinds of teeth.

The calve`s lower incisors showed a higher dentine loss after abrasion only than after erosion only ($p=0.0054$). When comparing cattle`s lower incisors dentine wear due to erosion or abrasion no significant difference was found ($p=0.258$).

In contrast, the dentine wear due to erosion only was significantly higher as compared to abrasion only for human teeth ($p<0.0000$ and $p=0.0006$).

Comparing dentine wear due to erosion only, a significant difference between human third molars and deciduous molars ($p=0.0456$) as well as cattles and calves lower incisors ($p=0.0402$) was found.

When comparing adult human dentine of third molars with cattle`s dentine, it is noticeable that there was no significant difference for the tooth wear by erosion/abrasion ($p=0.7002$). However tooth wear induced by erosion was higher for human third molars than for cattle`s lower incisors ($p<0.0000$). Also the deciduous molars show a significantly higher dentine wear due to erosion only compared with calve`s lower incisors ($p<0.0000$).

Discussion

In the present study, tooth wear due to erosion and abrasion only as well as for erosion/abrasion was recorded by using the surface profilometry method with a custom made computer program. This method is often used for the recording of tooth wear.[18-20] When using surface profilometry, only the depth of the lost dental hard tissue can be recorded. However demineralised softened dentin, or the thickness of the demineralised collagen matrix could not be detected.

The present results of finding a higher dentine wear due to erosion/abrasion than for erosion or abrasion only confirm previous findings.[2,3] These studies also found that eroded dentine is more susceptible due to mechanical abrasion than sound dentine.

In the present study no significant difference in dentine wear due to abrasion only was found. However, significantly lower dentine wear due to erosion only was seen for calves lower incisors and deciduous molars when comparing these substrates with the adult teeth of the respective species. Hunter[21] also found a lower dentine wear due to erosion for deciduous teeth than for adult human teeth, although this difference was not statistically significant. This findings do not seem to be consistent with the lower susceptibility of cattle`s lower incisors and human third molars to erosion/abrasion as observed in the present study. However, it should be noticed that in a previous study the mineral content of deciduous teeth was proved lower as compared to permanent teeth.[22] Thus it might be assumed, that the amount of non-mineralised collagen matrix is higher for deciduous teeth compared to dentine of permanent teeth. The effect of acid challange, which dissolves the mineral part of the dentine, might therefore result in a thicker layer of exposed collagen fibres in the deciduous teeth. The profilometric recordings of these surfaces will show a lower loss of dentine hard tissue for erosion only, although the acid might have produced higher and deeper loss of mineralized dentine tissue for the deciduous teeth, below the exposed collagen layer. It might be speculated that this exposed collagen matrix might be removed by mechanical forces like tooth brushing. This consideration would explain that the combination of erosion and abrasion in the present study led to higher dentine loss in the deciduous molars and calve`s lower incisors as compared to human third molars and cattle`s lower incisors.

A significantly higher dentine wear due to erosion only for primary and permanent human teeth was found compared to calves and cattle`s lower incisors. Pashley[23] described that human dentine allows better penetration with resin than bovine dentine. This observation might be explained with the higher percentage of dentine tubules surface in human dentine as compared to bovine dentine.[10] This higher

percentage of dentine tubules might be a reason for the better penetration of an acid into human dentine, so that a higher amount of human dentine could be dissolved in the same time as compared to bovine dentine. By contrast, Schmalz[15] found a higher permeability for bovine dentine then for human dentine, although these results were not statistically significant. This conflict might be explained by the fact that the distance from the pulp may be different in these studies.

However, beside these observations mentioned above, no statistically significant difference in the dentine wear due to erosio-abrasion of cattle`s lower incisors and human third molars was recorded in the present study.

Thus, it could be concluded that under the standard conditions used in the present study cattle`s lower incisors dentine might be an appropriate substitution for adult human dentine, when the susceptibility to erosion/abrasion should be tested. However for testing the susceptibility due to erosion only the substitutability of human dentine by bovine dentine under the present conditions is limited. In tests, where abrasion only is evaluated human deciduous or permanent dentine might be substituted by cattle`s or calves lower incisors dentine.

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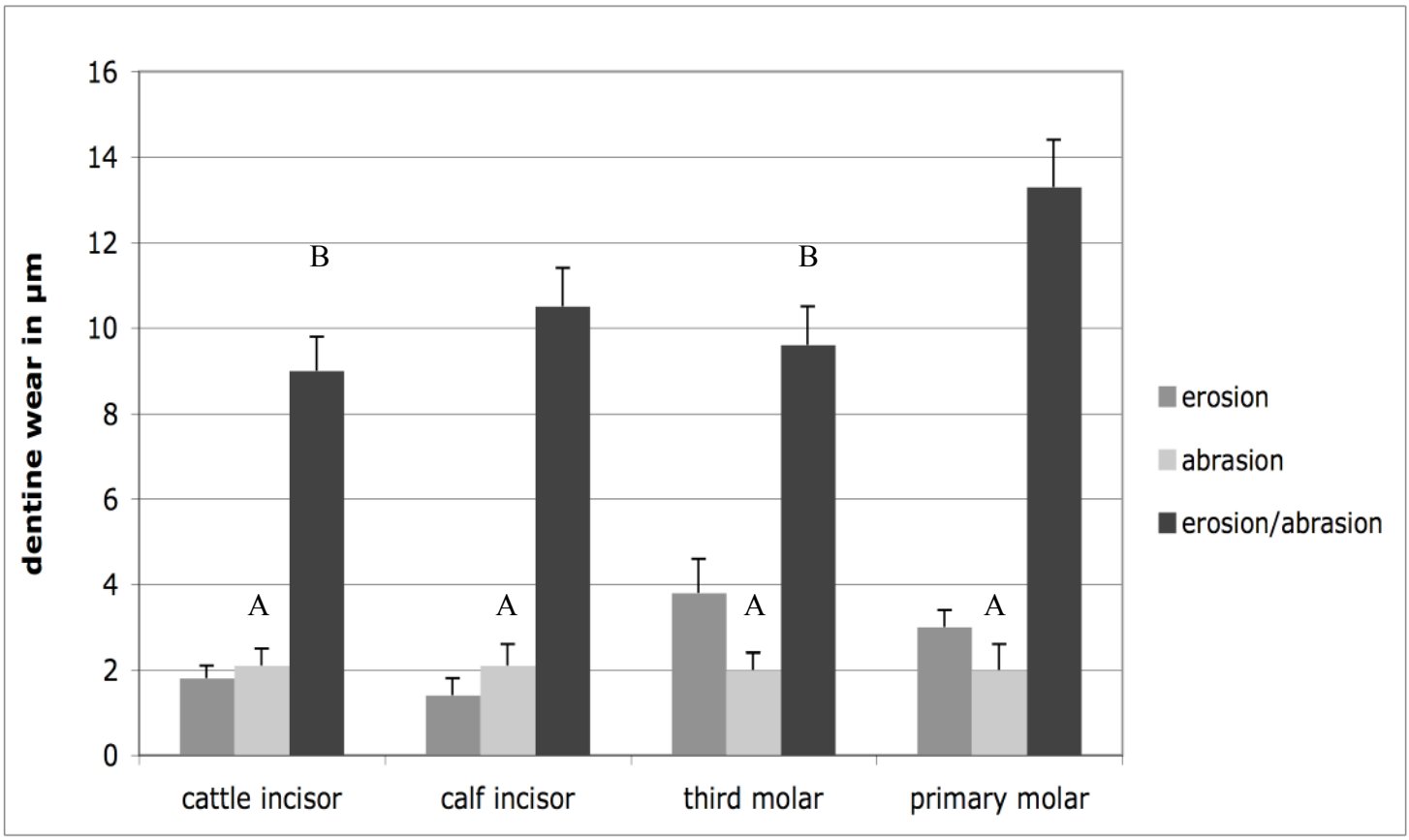

Fig. 1. Mean dentine wear (standard deviation) in the different tooth substrates after either erosion, abrasion or erosion/abrasion. Groups, which were not statistically significantly different within the same kind of treatment, are marked with same letters.

Table 1. Composition of the artificial saliva (in 100 ml distilled water)

Ascorbic acid	0.002g
Na_2HPO_4	0.340g
KH_2PO_4	0.330g
NaCl	0.580g
$CaCl_2$	0.170g
NH_4Cl	0.160g
KCl	1.270g
Urea	0.200g
Glucose	0.030g
NaSCN	0.160g
Mucin	2.700g