Researchers reveal new insights into the internal structure of dentine

By DTI

BERLIN, Germany: Being subjected to massive forces, human teeth consist of one of the most durable organic materials. To date, the high crack resistance of dentine has not been fully understood. An interdisciplinary team of scientists has now analysed the complex structure of dentine, revealing that its mineral particles are pre-compressed and internal stress works against crack propagation to increase the resistance of the bio-structure.

Engineers already use internal stresses to strengthen materials for specific technical purposes. Now it seems that evolution has long known about this trick and has put it to use in our teeth. Unlike bones, which are composed partly of living cells, human teeth are not able to repair damage. Their bulk is made of dentine, a bone-like material consisting of mineral nanoparticles. These mineral nanoparticles are embedded in collagen protein fibres, with which they are tightly connected. These fibres are found in every tooth and lie in layers, making teeth tough and damage resistant.

Researchers from the Julius Wolff Institute at Charité – Universitätsmedizin Berlin, together with several national and international partners, have examined these bio-structures more closely. They performed microbeam in situ stress experiments at the BESSY II synchrotron radiation source at Helmholtz-Zentrum Berlin and analysed the local orientation of the mineral nanoparticles using the nano-imaging facility of the European Synchrotron Radiation Facility in Grenoble.

When the tiny collagen fibres shrink, the attached mineral particles become increasingly compressed, the research team learnt. “Our group was able to use changes in humidity to demonstrate how stress appears in the mineral in the collagen fibres,” Dr Paul Zaslansky from the Julius Wolff Institute explained. “The compressed state helps to prevent cracks from developing and we found that compression takes place in such a way that cracks cannot easily reach the tooth inner parts, which could damage the sensitive pulp.”

In this manner, compression stress helps to prevent cracks from running through the tooth.

The scientists also examined what happens if the tight mineral–protein link is destroyed by heating. In that case, dentine becomes much weaker. “We therefore believe that the balance of stresses between the particles and the protein is important for the extended survival of teeth in the mouth,” Charité scientist Jean-Baptiste Forien stated.

Their results may explain why artificial tooth replacements usually do not work as well as healthy teeth do: they are simply too passive, lacking the mechanisms found in the natural tooth structures. Consequently, fillings cannot sustain the stresses in the mouth as well as teeth do. “Our results might inspire the development of tougher ceramic structures for tooth repair or replacement,” Zaslansky hopes.

The study, titled “Compressive residual strains in mineral nanoparticles as a possible origin of enhanced crack resistance in human tooth dentin,” was published in the Nano Letters journal on 26 May.

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“Xylitol is here to stay”

An interview with Professor Emeritus Kauko K. Mäkinen, Finland

Dental Tribune: Prof. Mäkinen, you were involved in the first extensive studies of xylitol in the seventies—how far has the sweetener come since then?

Prof. Emeritus Kauko K. Mäkinen: The awareness of xylitol among consumers and healthcare professionals has increased significantly since the early 1970’s. However, knowledge about xylitol is not equally distributed across the world. Although awareness may approach 100 per cent in Finland, the situation is different in other countries and the level of awareness depends on the level of dental and medical education in each country.

As you mentioned, in Finland, xylitol seems to be a part of daily life? Xylitol is indeed known by virtually all Finns and is also used by most people in Finland on a daily basis. Parents and grandparents have adopted a habit of buying xylitol gum, pastilles or lozenges for their children and grandchildren. At many day-care centres, children learn to use xylitol after lunch.

In Germany, for example, you can buy xylitol as a sweetener and it is also added in gum, but it is not widely known to the public as a mainstream product. Why do you think there is such a difference in “popularity”?

You are right about the situation in Germany. I cannot help but wonder why this could be, since xylitol was discovered by German chemists and its medical use in infusion therapy is best known by German physicians. It is possible that German dentists do not value early caries prevention as much as the dentists and the authorities do in Scandinavia. One would need a strong and committed distributor and an official endorsement from the German Dental Association.

When you did your research for the Turku studies, did you expect to find xylitol to be so beneficial, especially for oral health?

We did not anticipate the magnitude of this preventative effect. We considered it a welcome surprise. Later, of course, after learning how xylitol works and after we learned to understand the chemical mechanisms involved, we started to regard the findings as natural and expected.

Is there a measurable impact on caries levels and dental health that can be attributed to the sweetener?

We cannot give any figures of the effect of xylitol in caries incidence in the above instances. Overall caries prevention takes place as a result of multi-faceted efforts and programs, xylitol being a part of the whole. It is impossible to differentiate between the effect of each individual preventative measure since all of them are in action simultaneously, such as tooth brushing, the use of fluorides, the application of sealants, etc.

The caries preventative effects of xylitol that were reported in the literature are based on clinical trials. Xylitol does, however, significantly increase the efficacy of overall caries prevention, provided that the use of xylitol is habitual and is based on the consumption of sufficiently-large daily amounts that are taken at least three to five times a day.

Do you have any data on how much xylitol is consumed in Finland or worldwide?

These figures are possessed by xylitol manufacturers and they do not provide any production-related information to us. However, the annual production worldwide must be tens of thousands of tons since xylitol is produced in China, Russia and in other countries. The first true xylitol plant in the world was in Finland and was sold to DuPont a few years ago. When production started in Finland in the 1970’s, 3,000 to 50,000 tons were made during the first few years, but overall, production is by far much larger now.

How should the sweetener be used in daily life?

My current recommendation is about 7–10 g per day, evenly distributed throughout the day. The first dose in the morning, the last after oral hygiene at bedtime. Always after meals and sugary snacks. Use it about 5 times a day, not less. Use two pellets or one stick of gum, but the gum must be 100 % xylitol. One may “tolerate” some maltitol in it, but no sorbitol, unless the sorbitol amount is very small (<5 %). Some companies use only 5–10 % xylitol and call their product “a xylitol gum”, which is false.

Are there any known side effects?

Regular consumers who use xylitol for dental purposes have no side effects. If somebody accidentally consumes larger single doses, for example, 20–30 g, some individuals may have transient diarrhea. However, sorbitol, mannitol and combative products cause much more severe symptoms. Of course, small children must use xylitol gum under parental guidance.

Do you think xylitol could be playing a greater role in the future, maybe in developing countries?

Xylitol is here to stay. We are already using xylitol in developing countries. Vietnam is one example and, in thinking, it is still developing country. Xylitol is currently being used in hundreds of dental, medical, cosmetic and other products all over the world. Its popularity is increasing steadily, but not abruptly.

Thank you very much for the interview.