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 – University Medicine 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.
During the early 1970’s, xylitol and other natural sweeteners were extensively tested in Finland as potential replacements for sugar. The series of over 20 research reports published together in Acta Odontologica Scandinavica in 1975, became collectively known as the "Turku Sugar Studies". Approaching 20 research reports, published together sively tested in Finland as potential re-
other natural sweeteners were exten-
During the early 1970’s, xylitol and
xylitol is indeed known by vir-
and is also used by most people in Finland on a daily
basis. Parent's and grandparents have
 adopted a habit of buying xylitol
gum, pastilles or lozenges for their
carries levels, its popularity in Finland and the sweet-
ener’s future prospects.
As you mentioned, in Finland, xylitol seems to be a part of daily life?
Xylitol is indeed known by virtu-
ally all Finns and is also used by
most people in Finland on a daily

Yet even closer to nature – LuxaCore Z.

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 con-
sumers and healthcare professionals
has increased significantly since the early 1970’s. However, knowledge
about xylitol is not equally distrib-
uted across the world. Although
awareness may approach 100 percent
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.

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 endorse-
ment 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 mag-
nitude 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 mecha-
nisms involved, we started to re-
gard 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 preven-
tative 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 lit-

"Overall caries prevention takes
place as a result of multi-faceted
efforts and programs, xylitol being
a part of the whole."