Case 1

Speaker and Guest Expert

Nearchos C. Panayi is an orthodontist based in Limassol, Cyprus. He is a scientific collaborator at the European University Cyprus, Dental school and a visiting Research Scientist at the Clinic of Orthodontics, Center of Dental Medicine, University of Zurich, in Switzerland. He studied dentistry at Athens Dental School (1992–1997) and orthodontics at Tel Aviv University (1998–2001) before building his private practice, which has grown into two fully digital orthodontic offices in Limassol and Larnaca, Cyprus. His passion for digital technology encouraged him to use it in orthodontics, and as a huge fan of the in-house 3D designing and printing concept in orthodontics, Dr Panayi has helped develop concepts, ideas, and methods that will transform traditional orthodontics to customized-centered digital orthodontics. He is the inventor of the orthodontic CAD software Ubrackets for in-house designing of customized fixed orthodontic appliances, and he introduced the use of general-purpose CAD software in orthodontics for orthodontic appliance design. He is the editor of «DIY, Design It Yourself Orthodontics» book that was released by Quintessence USA in July 2021. He is a co-author in other orthodontics books and published articles on in –house customized brackets, printed aligners and bracket material research. He is an associate editor of the "Progress in Orthodontics" journal.

Martyn Cobourne is Professor and Academic Head of Orthodontics in the Faculty of Dentistry, Oral & Craniofacial Sciences at King's College London. He graduated in Dentistry from King's College London in 1990 and undertook orthodontic specialty training at King's College Hospital from 1994-1997. From 1998-2002, he was a MRC Clinical Training Fellow in Paul Sharpe's laboratory at Guy's Dental Hospital and completed a PhD in developmental biology. He was appointed as a Senior Lecturer and Hon Consultant in Orthodontics at King's College London in 2004 and promoted to Professor of Orthodontics in 2011. He has published >180 original articles and is the author of four textbooks. He was a Trustee and Director of Research at the British Orthodontic Society (BOS) (2012-16) and has been Editor-in-Chief of the *Journal of Orthodontics* for the last decade.

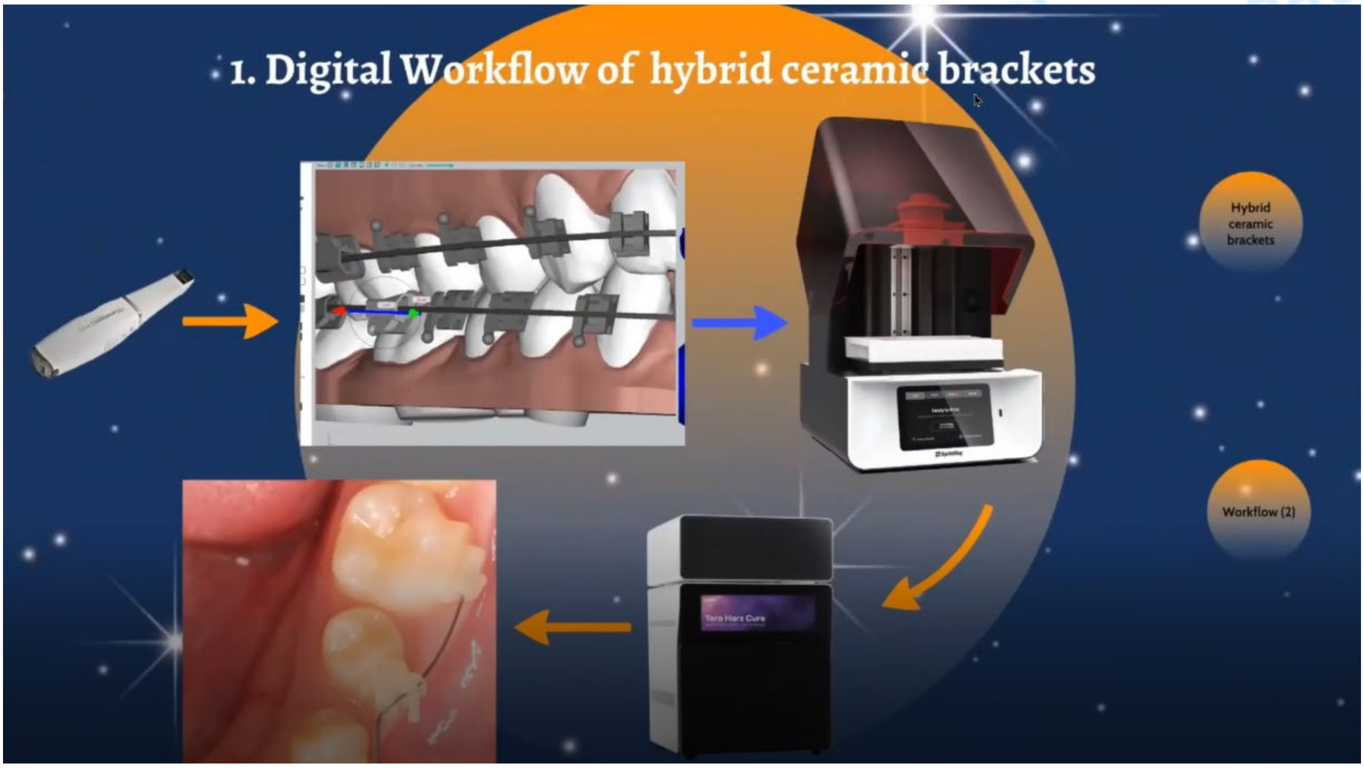
3D printing technology is widely used in the field of orthodontics. However, 3D printing technology still has many problems, such as the complicated procedure, high requirements for technical support and high costs of the equipment. At the same time, the accuracy of the customized buccal or lingual brackets needs to be improved, the mechanical and biological properties need further investigation.

Straight-wire technique has served the orthodontic community for almost 50 years. Nevertheless, the one-size-fits- all approach is not suitable for the range of malocclusions and tooth morphology. In the case of customized brackets, in-house designing and printing have some advantages over traditional commercial brackets. The ability to create a setup that will be the desirable orthodontic treatment with the concept of 'treatment with the end result in mind' [1].

Key points of Dr. Panayi's talk were as follow

Workflow of 3D designing and printing customized brackets

- Acquisition of digital dental model by intra oral scanner
- Orthodontic CAD software for brackets designing (currently Ubrackets): teeth segmentation and setup; customized brackets positioning on the teeth; positioning keys designing etc.
- Stereolithography 3D resin printer or 3D zirconia printer
- UV curing unit and resin machine washer
- Sintering for zirconia bracket



Ubracket software (Coruo, Limoges, France)

- A customized bracket design software, which can be used for both labial and lingual brackets
- Two customization options: 1) Fully customized brackets; 2) Base customization of commercial brackets
- The software library includes various types, sizes and materials of the brackets
- The brackets are aligned on a flat 0.018 ×0.025-inch virtual archwire and can be rotated and moved in labiolingual or mesiodistal direction and around its vertical axis using a special manipulator
- Virtual arch wire design, the actual arch wire can be bent on a 1:1 ratio archwire drawing exported as a PDF file manually or by wire-bending robot

3D printer and printing materials

	Hybrid ceramic resin	**Zirconia bracket**
printer	resin printer	zirconia printer
raw material	resin	zirconia slurry
post-printing procedure	clean the excess uncured resin (special washing machines); UV curing	sintering; zirconia coloring: 1) zirconia slurry with different shade of white (A0, A2) 2) transparent zirconia 3) coloring of zirconia

Mechanical properties

- Ideal commercial brackets: high hardness; high elastic modules (slot walls, wings); low elastic modules base and high toughness
- Ideal 3D printed brackets: high hardness; high elastic modulus and high toughness
- Commercial plastic bracket showed very low hardness. Printed bracket showed double hardness values compared to the commercial plastic one [2]

Future trends

- Although the whole design workflow is quite fast, artificial intelligence (AI) will be included to increase the speed of designing
- As the technology becomes more widespread, competition and innovation increase, the cost of 3D printers will decrease
- A full customization process should include mechanical customization, together with biological customization. Further in-depth research is needed to help to achieve a more predictable orthodontic result

References

[1] Panayi N C. In-house three-dimensional designing and printing customized brackets. *J World Fed Orthod*. 2022.

[2] Eliades T, Gioka C, Zinelis S, et al. Plastic brackets: hardness and associated clinical implications. *World J Orthod*. 2004, 5(1).

Case 2

Speaker and Guest Expert

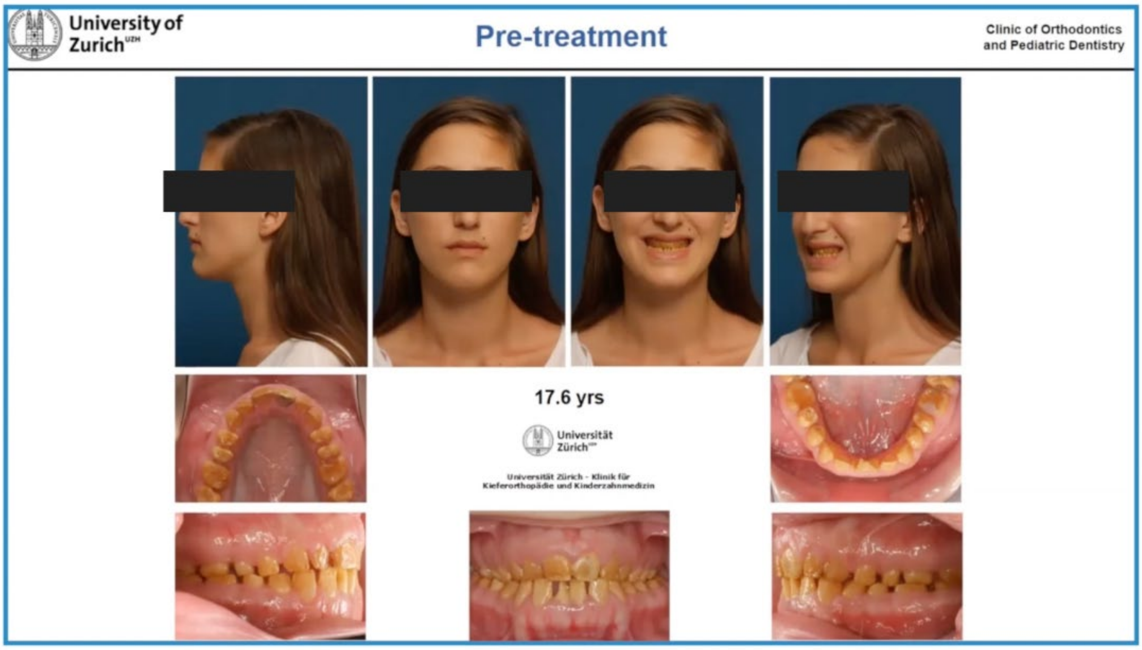
Spyridon Papageorgiou is a clinic coordinator and deputy director at the clinic of Orthodontics and Pediatric Dentistry, Center of Dental Medicine of the University of Zurich (Switzerland) and a visiting senior lecturer in King's College (London). He graduated from Aristotle University of Thessaloniki (Greece), while he completed his orthodontic specialty training & doctorate (Summa Cum Laude) from the University of Bonn (Germany). In 2021 he received his Habilitation (Venia Legendi) and in 2022 a Certificate of Advanced Studies in Orthognathic Surgery – both from University of Zurich, while he completed a MSc on Medical Research Methodology from Aristotle University of Thessaloniki. He has published over 170 papers in international peer-reviewed journals and over 10 chapters (4500 citations; h-index: 40; i10-index: 91), acts as a reviewer (>30 journals), academic editor (3 journals), statistical advisor (1 journal), (co-)supervisor / examiner over 10 theses/dissertations for 4 universities. He worked on basic science, clinical trials, and evidence-based research funded by the German Research Foundation (2013), the Greek & German State Scholarship Foundations (2015), and the European Orthodontic Society (2016). His work has received multiple awards, including the David L. Turpin Award for Evidence-Based Research (2012) and the B.F. and Helen E. Dewel Award for Clinical Research (2018) from the American Association of Orthodontists, the W.J.B. Houston Award (2017) from the European Orthodontic Society, the Chapman Prize (2018) from the British Orthodontic Society, and the Best Research Award (2015) from the Greek Orthodontic Society. He has been invited to participate in consensus-meetings for the development of clinical recommendations from the European Academy of Osseointegration (2018), the Osteology Foundation (2022), and the European Federation for Periodontology (2022). His research focuses on the clinical outcome, duration, or side-effects of orthodontic treatment, evidence-based methods including randomized trials and meta-analysis, methods to identify bias in orthodontic clinical research, open / transparent research practices, and the effect of systematic diseases on the biology of orthodontic tooth movement.

Vaska Vandevska-Radunovic received her DMD and MSc in orthodontics at the University "Kiril i Metodij" in Skopje. She continued her orthodontic training at the University of Bergen, Norway 1990-1992, where she obtained her PhD (doctor odont) in 1998. She is currently Professor and Head of the Department of Orthodontics, University of Oslo, Norway and is involved in the education and research activity of graduate, post-graduate and doctoral students. For six years she was a member of the Continuing education committee of the Norwegian Association of Orthodontists. She is President of the EOS in 2023 and Secretary of the NEBEOP Board. She is Associate Editor of Clinical and Experimental Dental Research and The Korean Journal of Orthodontics. She is also member of the Editorial board of the World Journal of Orthodontics and

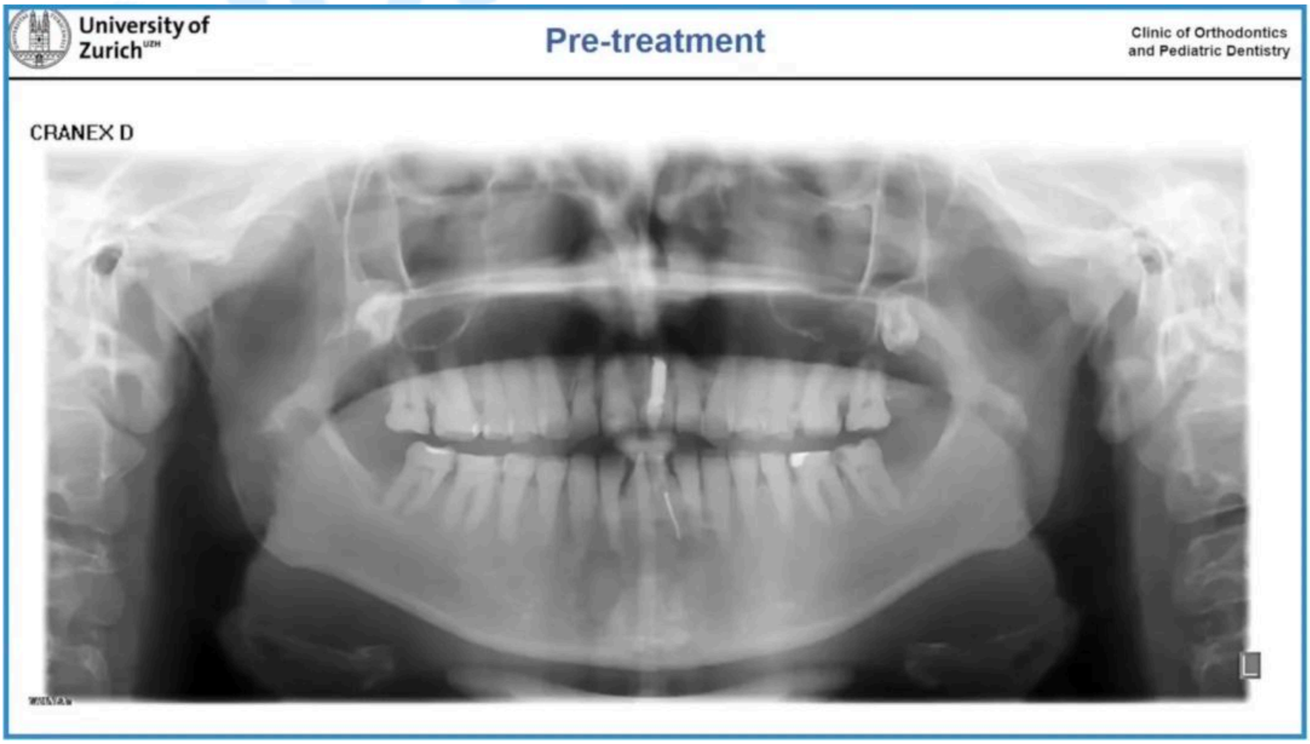
Acta Odontologica Scandinavica. Her main areas of interest are tissue reactions during orthodontic tooth movement and relapse, retention procedures and long-term outcome of orthodontic treatment and the effect of orthodontic treatment on periodontal health.

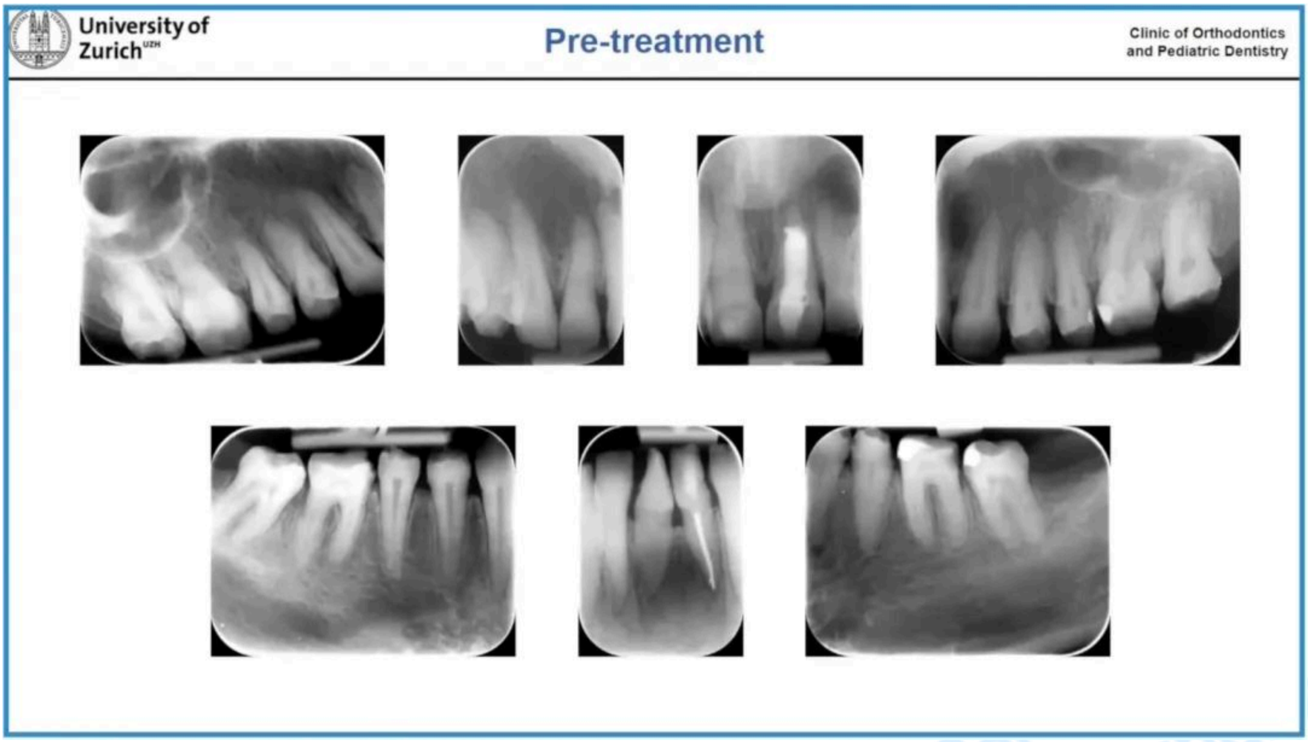
Case Report

- 17.6yrs female patient with amelogenesis imperfecta
- Angle Class I malocclusion, spacing in the upper and lower arches, crossbite, dental midline deviation



- Radiographs:
  1) Cephalogram: hyperdivergent facial type, skeletal Class I, open bite tendency;
  2) Panoramic radiograph: caries, dental fillings & root canals;
  3) Periapical radiograph: dentin is visible, but not the enamel


University of Zurich
Pre-treatment
Clinic of Orthodontics and Pediatric Dentistry
CRANEX D



- Treatment: Bone-supported rapid maxillary expansion to correct maxillary width deficiency;

Upper-arch: sodium hypochlorite as a deproteinizing agent to optimize orthodontic bonding, alignment and leveling of the upper-arch;

Lower-arch: the final esthetics is achieved by prosthetic reconstruction due to the limited amount of the enamel for bonding.

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Use of sodium hypochlorite

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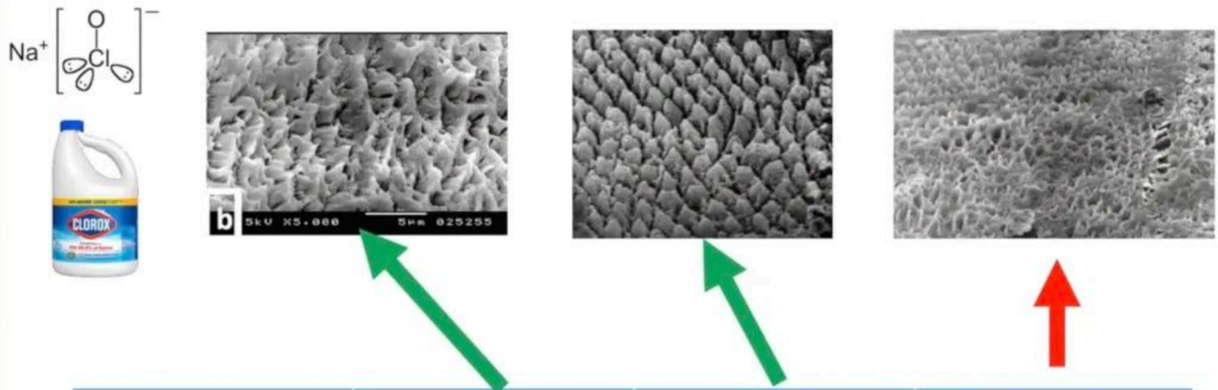


	Type I Pattern	Type II Pattern	Type III pattern
Conventional	25%	9%	66%
Plus NaClO	47%	36%	18%

Ahmed AM, Nagy D, Elkateb MA. Etching Patterns of Sodium Hypochlorite Pretreated Hypocalcified Amelogenesis Imperfecta Primary Molars: SEM Study. J Clin Pediatr Dent. 2019;43(4):257-262.

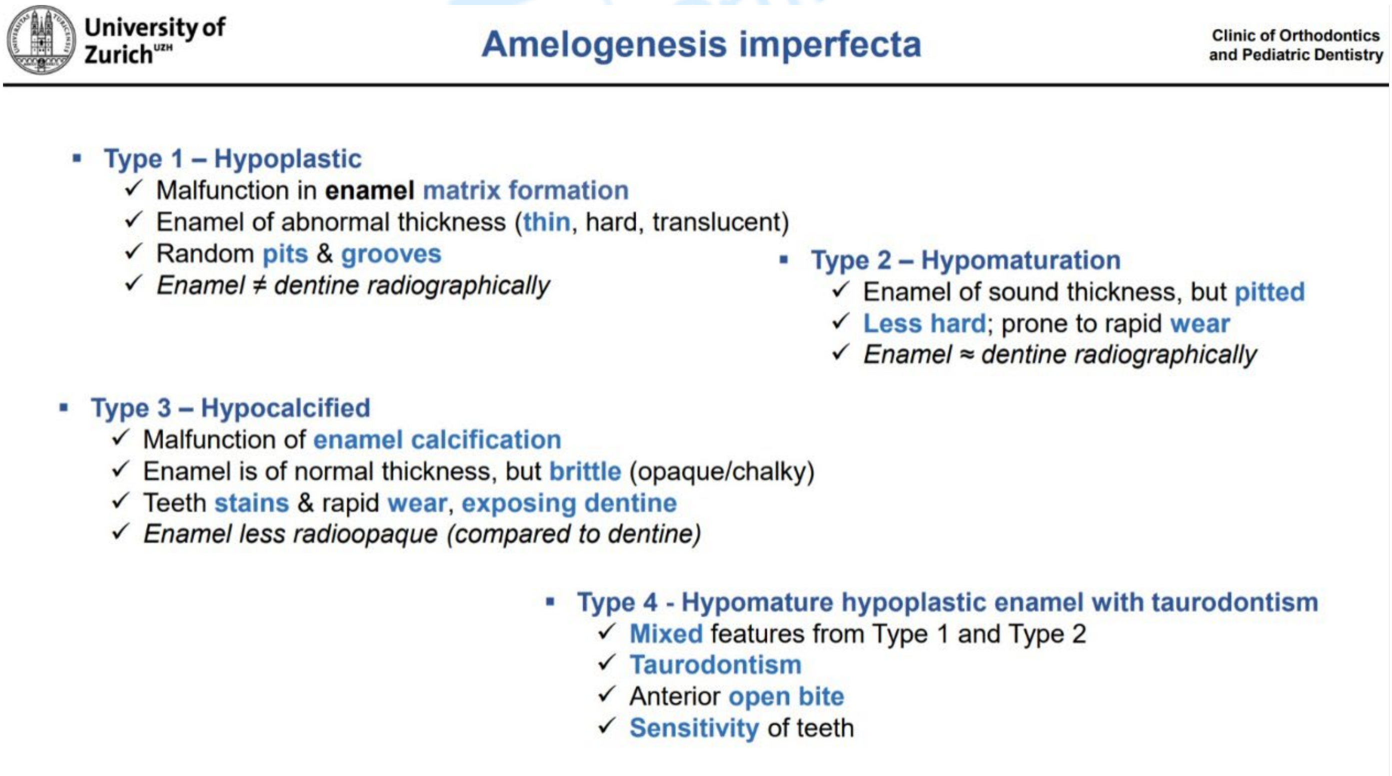
University of Zurich[UZH]

Mid-treatment

Clinic of Orthodontics and Pediatric Dentistry

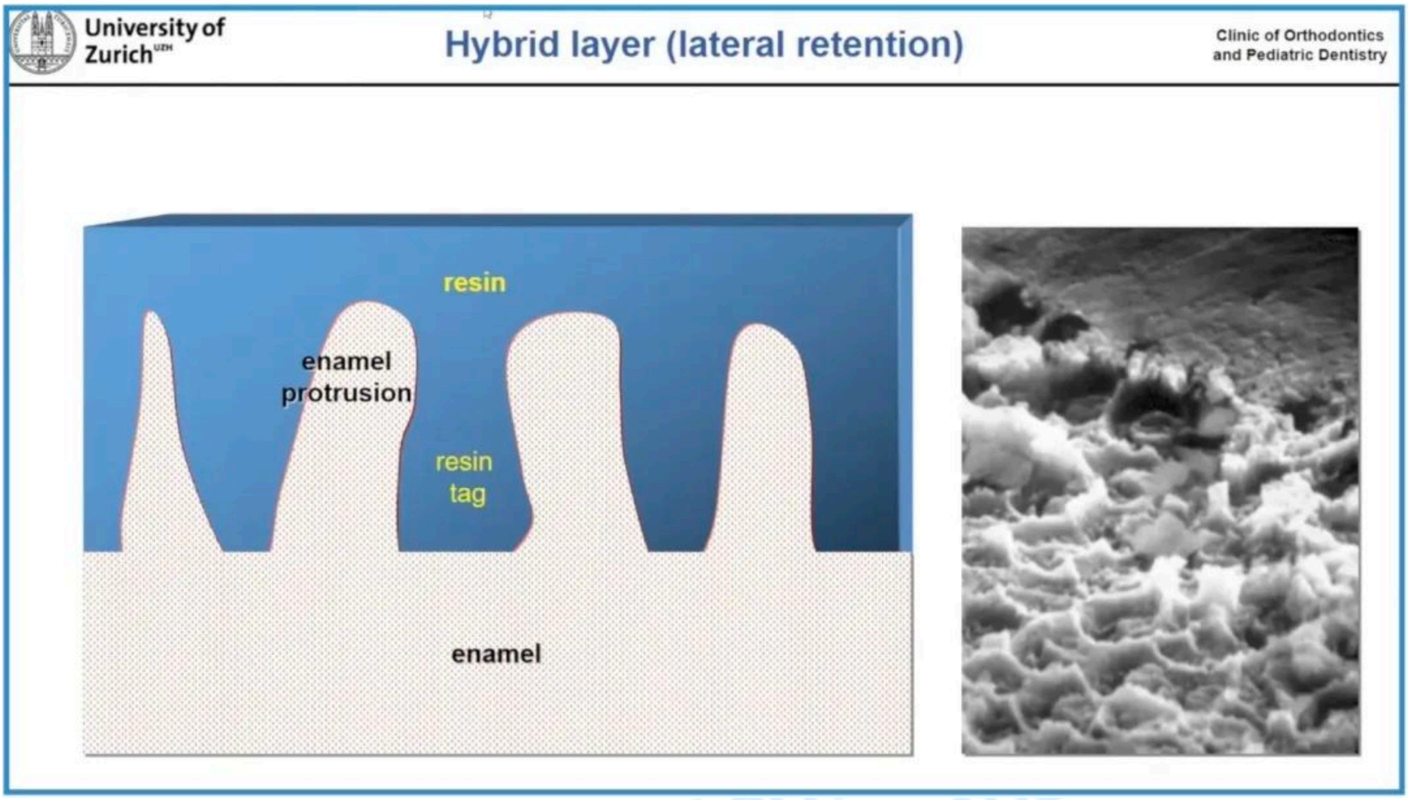
Amelogenesis imperfecta

Amelogenesis imperfecta encompasses a complicated group of conditions that demonstrate developmental alteration in structure of the enamel in the absence of a systemic disorder.



Principle of enamel bonding

The enamel consists of 96% inorganic and 4% organic and water content and is the most mineralized tissue [1]. After the enamel is thoroughly etched and rinsed with acid etchant, it will be demineralized to form a honeycomb like microporous layer. The mechanism of bonding to enamel is thought to be primarily based on micromechanical interlocking of resin into etch pits [2].



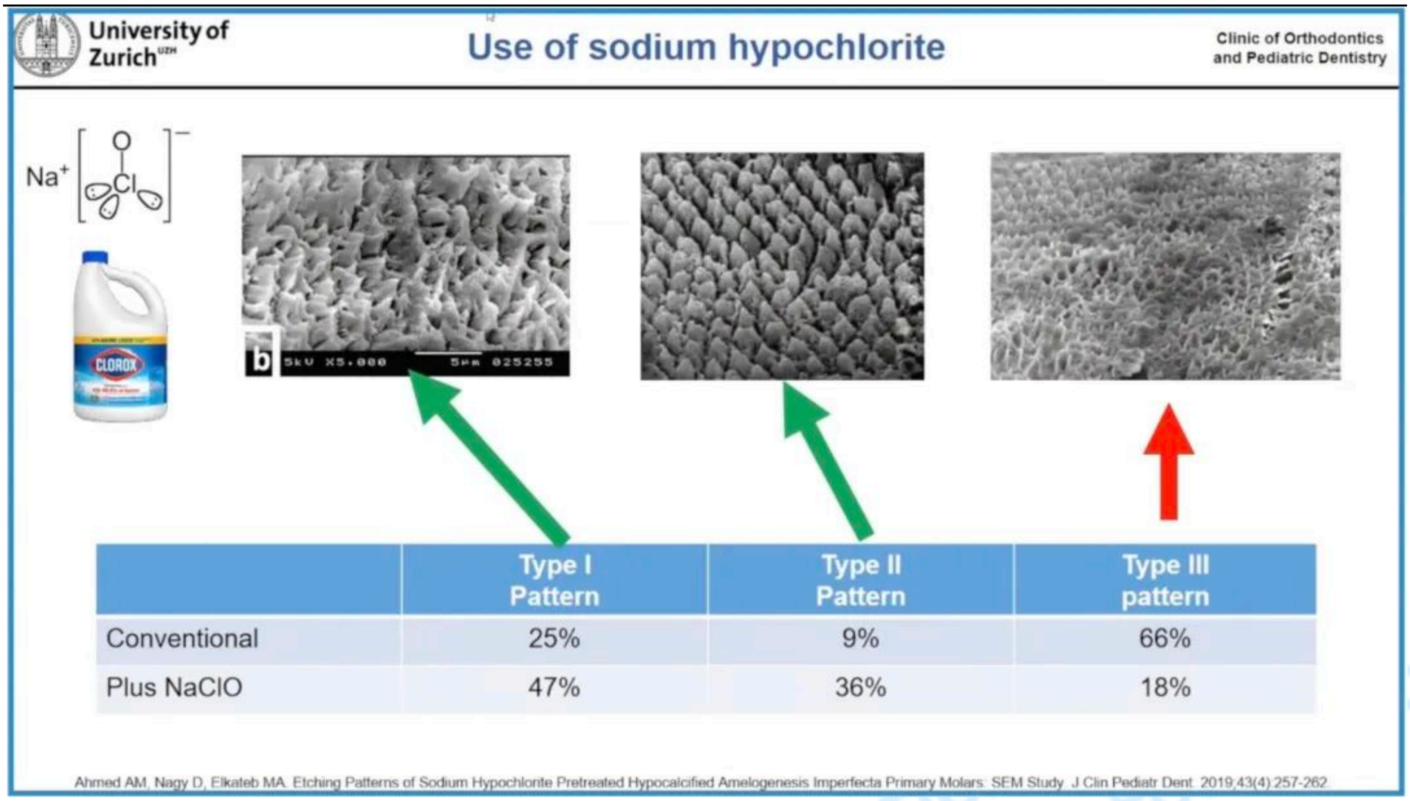
Effect of sodium hypochlorite (NaClO) deproteinization on orthodontic bracket bonding

There are many pores in enamel microstructure of patients with amelogenesis imperfecta. The proportion of protein content in enamel is greatly increased compared with that in non-affected. These characteristics determine that the bonding strength between the tooth surface and the adhesive is insufficient when bracket bonding is needed.

Sodium hypochlorite (NaClO) is a commonly used root canal irrigating agent in oral medicine, but it is rarely used in orthodontics. NaClO is an effective protein denaturant and removes excess protein on the surface of enamel, which can increase bond strength in bonding to teeth affected by amelogenesis imperfecta or fluorosed teeth [3]. Dr. Papageorgiou used this method in the case reported.

Fejerskov et al. found that the enamel of young permanent teeth has low hardness values and with many micropores than that of the mature permanent teeth [4]. Increase the acid concentration and etching time on will only make the enamel surface rougher, not sufficiently increase its bonding strength [5]. Aras et al. found the deproteinization with NaClO after acid etching significantly enhanced the shear bond strength values in primary and immature permanent teeth [6].

In the talk, Dr. Papageorgiou also provided the scanning electron micrograph of enamel surface after etching. Among them, Type I and Type II etching patterns are preferable. They have larger etching area and smooth enamel surface than type III. Applying NaClO to the enamel surface eliminates the organic elements. This effect allows the acid etchant to penetrate more effectively into the enamel, creating Type I and Type II etching patterns



	Type I Pattern	Type II Pattern	Type III pattern
Conventional	25%	9%	66%
Plus NaClO	47%	36%	18%

Orthodontic bonding for special clinical conditions

- Teeth with fluorosis: micro-abrasion; adhesion promoter; self-etching primer
- Bleached teeth: wait 3-4 weeks
- Composite-restored teeth: surface preparation (bur); sandblasting; silane; 37% phosphoric acid + sealant
- Ceramic-restored teeth: micro-etch; hydrofluoric acid 4-10%; Porcelain conditioner (silanization)
- Metal restored teeth: sandblasting; abrasion(bur); metal primer

References

[1] Beniash E, Stifler CA, Sun CY, Jung GS, Qin Z, Buehler MJ, et al. The hidden structure of human enamel. *Nat Commun*. 2019;10(1):1–13.

[2] Sato T, Takagaki T, Hatayama T, Nikaido T, Tagami J. Update on enamel bonding strategies. *Front Dent Med*. 2021;2:1–10.

[3] Ayman E, Amera A, Am K. Sodium hypochlorite as a deproteinizing agent optimize orthodontic brackets adhesion using resin modified glass ionomer cement. *Austin J Dent*. 2016;3(3):1037

[4] Fejerskov O, Josephsen K, Nyvad B. Surface ultrastructure of unerupted mature human enamel. *Caries Res*. 1984;18(4):302–14.

[5] Nguyen TT, Miller A, Orellana MF. Characterization of the porosity of human dental enamel and shear bond strength in vitro after variable etch times: Initial findings using the BET Method. *Angle Orthod*. 2011;81(4):707–15.

[6] Aras S, Küçükeçmen H, Öaroğlu SI. Deproteinization treatment on bond strengths of primary, mature and immature permanent tooth enamel. *J Clin Pediatr Dent*. 2013;37(3):275–80.

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