THE CUTTING EDGE

This column is compiled by JCO Technology Editor Marc S. Lemchen, DMD. To help keep our readers on The Cutting Edge, Dr. Lemchen will spotlight a particular area of orthodontic technology every few months. Your suggestions for future subjects or authors are welcome.

Not too long ago, almost none of us in the orthodontic profession had even heard, much less used, the phrase "digital workflow." In the past five years, however, orthodontists have begun to understand the importance of how their digital data might move from acquisition to evaluation into design, production, and finally delivery of an orthodontic device to the patient. The "flow" of this data can play a critical role in the efficiency and accuracy of orthodontic appliances produced from digital data.

Aligners, of course, have helped usher us into the digital workflow era, particularly after the development of intraoral scanners that acquire data directly from the patient. Aligners involve a digital workflow that many now use, but rarely think of as a "digital workflow."

Now that there are several biocompatible materials that can be used to mill or three-dimensionally print an orthodontic device, a digital workflow becomes even more critical to the process. This month's article describes the use of a biocompatible material called PEEK (polyetheretherketone) to print or mill a retaining device that can be bonded to the lingual surfaces of the maxillary or mandibular anterior teeth. The digital workflow is followed from data acquisition with a scanner to appliance milling or printing, right up to cementation of the retainer in the patient's mouth.

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A Fully Digital Workflow for PEEK Fixed Retainers

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Digital technologies and new materials have provided orthodontists with a variety of options for both active treatment and retention.[1,2] For example, while fixed retainers are traditionally made from stainless steel or metal alloys, we sometimes need different materials to treat patients with metal allergies or other issues requiring metal-free devices.[3,4]

Among the polymers that have recently been introduced in dentistry and orthodontics, PEEK has been proposed as a viable alternative to metal.[5] PEEK is a semicrystalline linear polycyclic aromatic polymer that was developed in 1978 and later commercialized for industrial purposes.[6] By the late 1990s, PEEK had become prominent as a high-performance thermoplastic used in orthopedic surgery.[6]

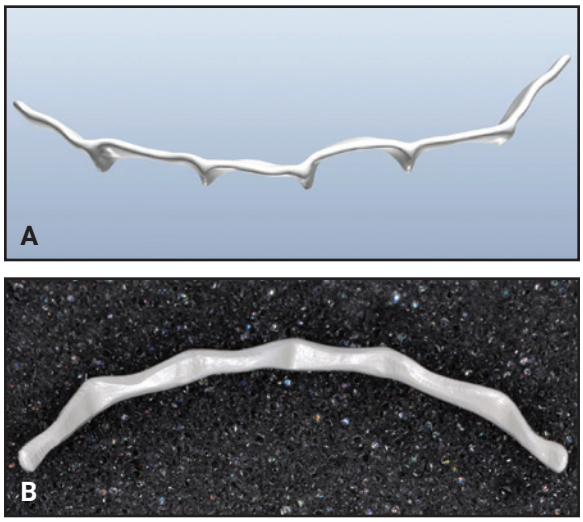

Fig. 1 Case 1. A. STL file of lower 3-3 retainer. B. Finished retainer milled from PEEK.

PEEK is a white, radiolucent material with thermal stability up to 335.8°C.[7] Its mechanical properties do not change during sterilization.[8] The flexural modulus of PEEK is 140-170MPa, and Young's elastic modulus is 3-4GPa—close to that of human bone, enamel, and dentin. It is hypoallergenic, nontoxic, and biocompatible, with low plaque affinity.[8,9] In an in vitro comparison of PEEK to polymethyl methacrylate (PMMA) and composite resin, Liebermann and colleagues found that PEEK had the lowest solubility and water absorption.[10]

Dental devices made with PEEK can be either milled or 3D-printed, offering versatility in production.[11] This article demonstrates how fixed PEEK retainers can be made by both methods, using a fully digital workflow.

Case 1

A 70-year-old male presented with a Class I malocclusion, crowding, and periodontal problems. He was treated for 12 months with the Invisalign* system.

After alignment was completed, a TRIOS** scanner was used to acquire complete intraoral scans of both arches. The stereolithographic (STL) file was sent to the dental laboratory for design and fabrication of a lower 3-3 PEEK retainer, using computer-aided design (CAD) software*** and computer-aided manufacturing (CAM) with a G5† milling machine (Fig. 1).

At the delivery appointment, a trial fit of the retainer was performed (Fig. 2). The PEEK was

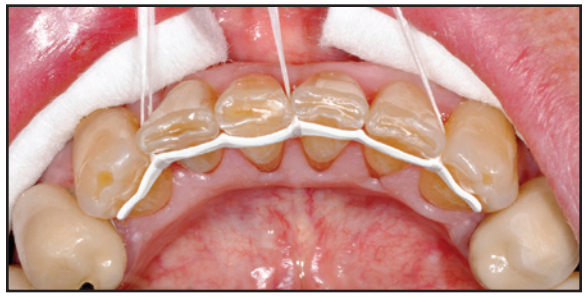

Fig. 2 Case 1. Fit tested on lingual surfaces of lower anterior teeth.

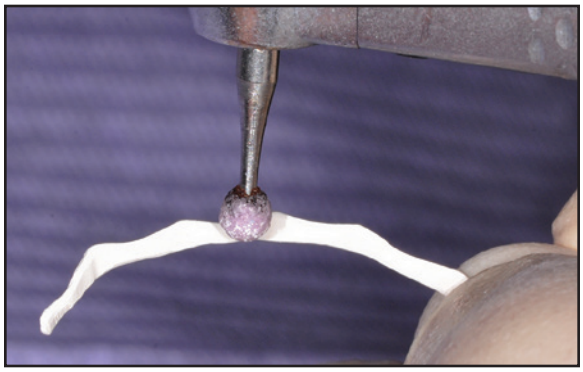

Fig. 3 Case 1. Retainer roughened with diamond bur.

Fig. 4 Case 1. Retainer held in place with dental floss for bonding.

then roughened with a diamond bur (Fig. 3), and a silane agent was applied with a microbrush and light-cured for 30 seconds. A 37% phosphoric acid etchant was applied to the lingual surfaces of the lower anterior teeth. Next, a thin coating of adhesive was applied to the teeth, taking care to leave the interdental contact points free, and light-cured for 20 seconds. The retainer was held in place with dental floss for bonding (Fig. 4). A composite resin was applied with a spatula to cover the retainer and the lingual surfaces and light-cured for 30 seconds (Fig. 5).

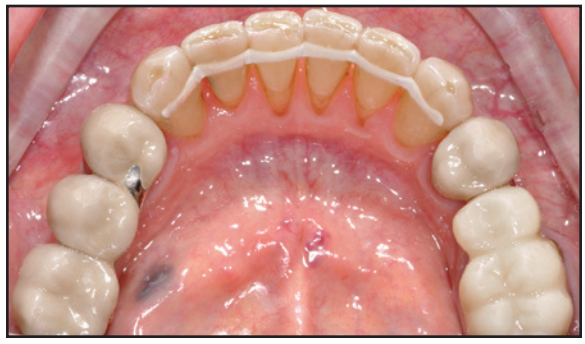

Fig. 5 Case 1. Bonded lower 3-3 PEEK retainer.

Fig. 6 Case 1. Patient nine months later.

Nine months later, the PEEK retainer was still stable and perfectly adapted to the lingual tooth surfaces (Fig. 6).

Case 2

An 11-year-old female presented with a Class II malocclusion, missing upper lateral incisors, a deep bite, and TMD. She was treated for 18 months with clear aligners in the upper arch and lingual orthodontics in the lower.

At the end of treatment, complete intraoral scans of both arches were acquired. A lower 3-3 PEEK retainer was designed as in Case 1 (Fig. 7). In this case, the retainer was fabricated using a 3D printer.‡ The bonding procedure was the same as in Case 1 (Fig. 8).

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**Registered trademark of 3Shape, Copenhagen, Denmark; www.3shape.com.
***Appliance Designer, trademark of 3Shape, Copenhagen, Denmark; www.3shape.com.
†Dental Machine Srl, Bobbio, Italy; www.dentalmachine.eu.
‡3DGence, Przyszowice, Poland; www.3dgence.com.

Fig. 7 Case 2. STL file of lower 3-3 retainer.

At the nine-month follow-up appointment, the patient demonstrated stable results and a perfect fit of the PEEK retainer (Fig. 9).

Discussion

Because of its biocompatibility, hydrolysis resistance, low plaque affinity, and flexular modulus close to that of enamel and dentin,[7] PEEK represents a viable alternative for the fabrication of customized orthodontic retainers. To date, however, few investigations have compared the properties of PEEK with those of metal wires.[12,13] One previous study showed how the dimensional stability and mechanical strength of this material made it suitable for the fabrication of space maintainers.[1] To our knowledge, this is the first report of the use of PEEK in bonded lingual retainers.

If a PEEK retainer becomes partially detached, the bonding procedure can be repeated. In case of breakage, a new PEEK retainer can be 3D-printed or milled in a short time.[14] This is an unlikely event, however, because of PEEK's high flexular modulus.[7] As with a conventional fixed retainer, it is not advisable to add a new parallel segment, which could lead to unwanted tooth movements.[14] If relapse occurred after failure of the retainer, the clinician would have to realign the teeth and perform a new intraoral scan for fabrication of a new device.[14]

Fig. 8 Case 2. Bonded lower 3-3 PEEK retainer.

Fig. 9 Case 2. Patient nine months later.

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