Dental burs are used to clean residual adhesive off teeth after orthodontic bracket removal. These burs incur wear degradation in the process. Can they be re-used on another patient or should they be single use only? Here we employ non-destructive 3D imaging of used burs by micro-CT to address this question.

As many teenagers and parents know, contemporary orthodontic treatment relies on aligning and moving teeth using adhesively attached orthodontic appliances (Fig. 1A). Dental composites and resins are used to bond orthodontic brackets (Fig. 1B) to the outer, typically labial tooth surfaces. Upon completing treatment, months or years later, both brackets and dental materials need to be removed (Fig. 1C).

**Figure 1**

Figure 1: To align teeth (A) orthodontists use brackets (B) and wires that apply forces to change tooth position and angle. Treatment ends (C) with bracket removal, when the teeth and dental arches have reached aesthetic, harmonious well-matching relations leading to functional occlusion and pleasing smile.
Removal of the adhesive remnants is an integral part of treatment. It is a clinical challenge for the treating orthodontist, who must completely remove the adhesive from the tooth, without causing damage to any of the teeth. High-speed water-cooled burs are commonly used, requiring patience and precision and full patient cooperation. A variety of grinding tools are available for this task, for example, tungsten carbide burs (Fig. 2A, B).

Questions arise regarding the optimal use of such tools, and how to use them best.

**Material and Methods**

Figure 3 shows typical steps involved in post-orthodontic adhesive removal, using the flame-shaped H48L tungsten carbide bur (Komet Dental, Gebr. Brasseler GmbH & Co. KG, Lemgo, Germany). The flutes (Fig. 2) of the bur are tapered with an angle of 52° in the direction of rotation and a moderate quasi-orthogonal angle of 20° with respect to the shaft axis. This reduces chances of possible damage to tooth surfaces, if/when the bur touches enamel. This specific bur has 12 flutes and a diameter of 0.14 mm and comes with different shafts designed to meet all hand pieces available on the market.

**Typical Clinical use of the Bur Includes:**

- Removal of the brackets with pliers; detachment frequently occurs in the bracket-adhesive interface (Fig. 2B)
- Grinding away of the composite residues from the tooth surface by repeatedly moving the water-cooled rotating bur across the polymer on the outer surface. The clinician must apply gentle pressure, allowing sufficient time for the bur to remove the adhesive
- From time to time, compressed air is used to dry the surfaces and find remaining contaminated tooth surface patches
- Polishing of the tooth surface is used to remove residues. For this, slow-speed rubber cups are used
- Application of fluoride is often indicated to increase enamel resistance to erosion or bacterial contamination.

**Figure 2**: These example burs are designed to gently remove polymer and composite adhering to the outer tooth surface. Although informative, the optical images (A) provide only partial information about the 3D design of the tool with little information on how it operates. Tomographic imaging (B) helps to better understand its mode of action.
To study the wear of the bur, micro-CT was used to record the 3D shape and details of the geometry of flute edges, using the high-resolution settings of a desktop instrument. The bur was imaged with a Bruker SkyScan 1275 micro-CT (Bruker micro-CT, Kontich, Belgium) mounted on a thin sample holder allowing positioning close to the X-ray source. The high density of elements in the bur necessitated using the higher source energy settings of 100 kV (yielding µA) and a Cu filter helped remove lower energies reducing significant edge artefacts. Best scans were obtained using 360° rotations, 6 µm effective pixel size. The image volumes were reconstructed using NRecon (V. 1.7.4.2, Bruker micro-CT, Kontich, Belgium).

Whereas 3D images may be produced instantaneously using CTvox (V3.0, Bruker micro-CT, Kontich, Belgium), the reconstructed data in slices is readily available as TIF or PNG files to be analyzed in any other package. Examples of typical cross-sectional slices obtained using the open-source ImageJ packages (https://imagej.net, V 1.52n) and its derivative, Fiji. Stacks of images make it easy to select, compare and measure changes in shape at precisely the same height in the sample both before and after use. In this manner it becomes possible to examine bur abrasion related to usage. Direct comparison between scans of a bur before and after a bracket removal session reveal selective zones.
Results & Conclusion

Superimposition of the virtual data obtained before and after bur use revealed that wear occurs in the central region up to two-thirds of the height of the bur. Wear never exceeded 1 mm in any direction (Fig. 6). The flutes are worn off significantly after usage and would thus require more force and longer treatment time to remove remaining composite on the tooth surface, with possible danger of tooth overheating.

These observations from 3D micro-CT imaging lead to a current recommendation to use a bur for just one debonding session in a single patient. However, comparisons with different usage protocols and bonding materials are still required to assess how general this single-use recommendation should be.

Figure 6

Figure 6: Superimposition and comparison of the bur volumes before and after use reveal important regionally varying differences in the amount of remaining substance (Tungsten carbide in this case). The green traces indicate a mismatch (averaging at about 130 µm in the flutes) with a clear trend for loss, as opposed to yielding or deformation of the flutes.