BY MICHAEL ALATSARIS

MIND THE GAP

Once upon a time, I had a lovely practice with a great team of colleagues and wonderful patients - many of whom had been attending for three or four decades. They regularly visited for appointments with our dental hygienist, followed our advice and invested in brushes and tools. However, I observed a prevalent oral health issue across 11 years that we simply could not overcome: those who had lost teeth were struggling to remove plaque from the remaining teeth adjacent to edentulous spaces.

The problem most commonly presented in patients with partial dentures – the almost cliché scenario for plaque stagnation at these sites. The prevalence of plaque in these groups was astonishing - seemingly affecting the vast majority of them. In fact, 74% of UK adults have lost at least one tooth, so total numbers were significant.[1]

In 2018, I conducted an in practice observational study of 209 of our patients to assess plaque accumulation on tooth surfaces adjacent to edentulous spaces. These patients had lost at least one tooth, excluding third molars, and had not restored the resulting space with a fixed prosthesis. For each patient, I examined the exposed mesial and distal surfaces bordering the edentulous area, excluding surfaces located behind 7s or 8s, and recorded the presence or absence of visible plaque at these sites. The findings showed that 94% of patients demonstrated plaque on at least one tooth surface adjacent to a missing tooth, indicating a high prevalence of inadequate cleaning in these anatomically challenging areas. I wondered whether this was a result of our quality of care!

I subsequently reached out to hundreds of other dental hygienists via LinkedIn in the UK, including 104 BSDHT members, and other English-speaking countries such as US, Canada and Australia. They all seemed to observe a high prevalence of the same problem! These clinicians complained of the inadequacy of the current available cleaning tools for exposed mesial and distal sites and were especially concerned for those patients wearing partial dentures. Indeed, it is well known that the abutment teeth are twice as likely to be lost compared to other teeth[2] (Fig.1).

Figure 1: **Plaque on RPD abutment teeth**

The general sentiment among these fellow dental professionals on LinkedIn comprised: frustration at observing active uncontrolled disease and deterioration at these stagnant sites; patients' reluctance to use currently available brushes; limitations of teaching patients a difficult technique which all too often failed; and the inefficient use of clinical time.

To quote a few:

"I often recommend an interspace brush for these types of gaps but only the very motivated patients keep it going long term. Most come back after a few months and say something like, I felt it wasn't doing very much."

"I currently recommend a large interdental brush as there is nothing else available. I also think that using the cap as a handle reduces the pressure you are able to apply and therefore biofilm isn't removed sufficiently."

"Currently there are no specific tools for this complaint, and for the few patients that do try, to clean this this area, they fumble with tools not designed for the task.

"This is a common problem and I have been an advocate of recommending single tufted brushes for nearly all patients, yet angulation is a challenge."

Figure 2: **Awkward single-tooth space**

The final frontier in oral hygiene?

As dentists, we are highly motivated to preserve the lone standing molar - often a critical tooth in the dentition. It may act as a posterior stop for the occlusion, maintaining the vertical dimension and taking load off the anterior teeth. From the patient's point of view, it may be their main 'chewing' tooth. It may be a denture abutment tooth, making their partial denture feasible, and without it, an impossibility. For example, when a bounded saddle becomes free ended at the loss of this tooth, it is a completely different challenge.

Ironically, where the patient may be able to see and access the exposed mesial surface of a lower seven - which may be mesially tilted - even if pointing the bristles of a toothbrush directly towards it, access is hugely impeded by the presence of the cheek. It prevents the handle coming round adequately to ensure the bristles are pointing straight to the back of the mouth.

And bizarrely, even the case of a missing anterior tooth presents challenges. As a single-tooth sized space, it often obstructs the access of even a small electric or manual toothbrush head. In which case, both teeth adjacent to the space suffer.

Residential carer-led toothbrushing for the elderly or hospitalised is also difficult. The ergonomics involved in using a toothbrush from in front or behind the patient are challenging. There is also the issue of any debris lingering at the edentulous spaces. In community dentistry, back in 2004, I was shocked to find my patient, who had recently suffered a stroke, presenting with a piece of food sitting in the affected side of her mouth at an edentulous space. She was totally unaware of its presence and I removed it before examining her. I wonder: how common is this scenario and how often is it attributed to aspiration pneumonia cases we see in our hospitalised patients? How often are food particles or clumps of florid plaque being inhaled or driven into the trachea during intubation?[3,4]

And more broadly, for those patients who transition to being house-bound, have we empowered them with a realistic home-care prevention regime to see them into their 80's, 90's and beyond, with limited hygiene care in the domiciliary setting?

Patient Sentiment and Trends

The patients exhibiting the aforementioned scenarios (and their carers) are generally a motivated cohort. Those with tooth loss tend to feel[5]:

- An increased fear of further tooth loss.
- That cleaning their teeth is awkward and messy.
- That cleaning should be easier.
- Sometimes helpless to control their oral health.

And the trends are not favourable[6]:

- The number of people with missing teeth is increasing.
- The number of people staying partly dentate is increasing, as fewer people move into the fully edentulous state.
- The use of partial dentures is increasing.

Anatomy-Led Toothbrush Design

Perhaps we have been making a grave assumption all this time that, when a tooth is lost, access is created to the newly exposed mesial or distal surface of the adjacent tooth. And so, if we can see it, surely patients can clean it?

I considered the anatomical barriers and the ergonomic challenges from a simplistic point of view and how one would clean a cube inside a tube - as this is what a patient faces when trying to clean a lone standing molar, for example. As a starting point, it was important to acknowledge which toothbrush designs work well in certain areas, and why that is. I felt it was necessary to categorise cleaning devices as dictated by the anatomy they address. It is the oral anatomy that creates the practical barriers we face in reaching and disrupting biofilm in our daily hygiene routine.

Category 1: Buccal, occlusal and lingual planes: large flat areas of dentition

The angle between the buccal or lingual tooth surfaces and their periodontium, is open, at around 160 - 200 degrees, and even greater in occlusal areas. With rows of two or more teeth, these essentially flat sections of the dentition support the relatively large area of the tips of a brush head. Its placement upon these tissues is the sound pairing of one surface against another (Fig.3). Hence, with minimal tuition the user can correctly position the brush head onto these planes with stability and achieve a high efficacy.

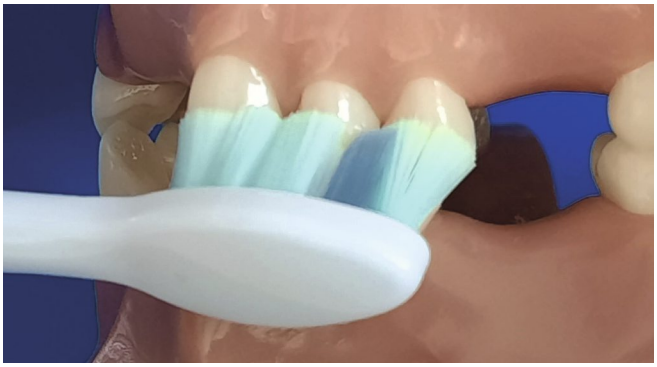


Figure 3: **Powered brush upon flat planes**

Figure 4: **Tissues that support interdental brushes along their long axes**

Category 2: Hidden mesial and distal sites – areas bound by adjacent teeth

These are trihedral recesses whose three surfaces can support, for example, an interdental brush, which has to operate and be stiff along its long axis. They maintain the bristles in correct positions, allowing their tips to work throughout brushing strokes. The use of floss and water flossers is also aided by this triad of surfaces in their positioning for interproximal cleaning (Fig.4).

Category 3: Exposed mesial and distal sites

Here we encounter the small, convex surface of just a single tooth. There is a very small surface to clean. Invariably, there is space and access for some kind of cleaning product.

Tall bristles from a powered brush being placed against a single tooth, are naturally unstable as they skip around upon it. There is far less tactile feedback for effective placement in comparison to brushing the large planes present in anatomy of Category 1. Moreover, the surface being cleaned requires repositioning of the whole toothbrush by 90 degrees on two planes – testing the spatial awareness and dexterity of the user, and usually impeded by the cheek. Furthermore, the tooth surface angle to the adjacent alveolar ridge is frequently less than 90 degrees - restricting access by a powered or manual toothbrush. Thus, the alveolar ridge itself becomes an obstacle when trying to place the bristles parallel to it (Fig. 5).

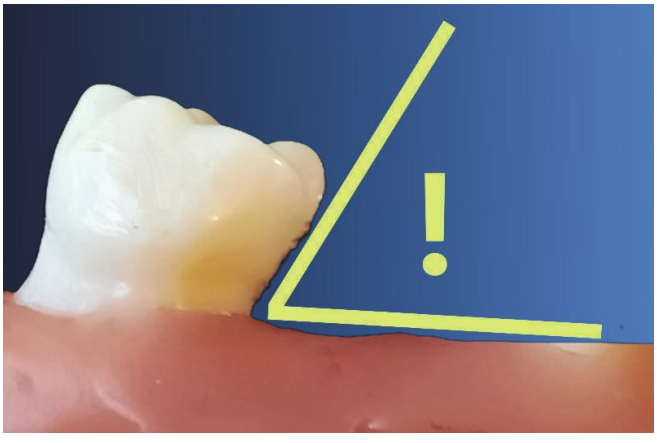


Figure 5: **Acute alveolar-tooth angle**

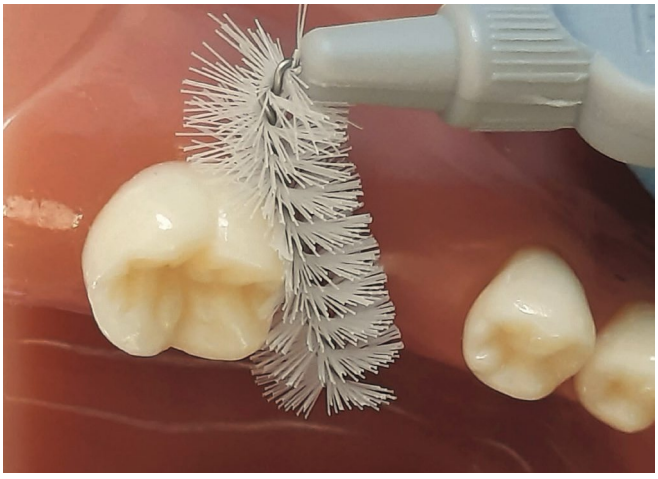


Figure 6: **Misuse of interdental brush**

Figure 7: **Single tufted brush unstable upon on a single tooth**

The use of one side of an interdental brush against a single tooth causes it to flex. Being suspended at one end, it is not designed for this purpose. As it deforms, tactile feedback and performance are lost. It also needs to be accurately bent by the user for each relevant tooth and so is excessively user-dependent. Hence, they cannot build technique nor maintain efficiency throughout the brush stroke and ultimately, are likely to give up on this application (Fig. 6).

A single tufted brush, having such a fine tip, is unstable when used against the convex surface of a single tooth. Again, there is poor tactile feedback and it becomes impractical, especially when used "blind", which so often is the case. To reliably use it here, patients would need a finger-rest technique, with a bent wrist, which is an unfair expectation on the general public to employ twice per day, for the rest of their lives (Fig.7).

Category 4: Recesses or nooks e.g., impacted wisdom teeth, orthodontic appliances, furcation lesions

These are a convergence of multiple surfaces meeting at acute or obstructed angles, limiting tool access. They offer a relatively stable seating area for something as narrow as a single tufted brush, for example.

Categories 5: Oral Mucosae, and 6. Removable prostheses and appliances

Although significant, these do not relate to the direct maintenance of the dentition nor the aim of this article.

The Status Quo

For as long as we prescribe inadequate toothbrushes for a certain category of anatomy, I foresee a number of barriers:

The patient must:

1. Be receptive to advice and demonstration from a dental professional.
2. Be relaxed and not distracted by fear of the dental setting.
3. Be able to be taught a new skill in their life.
4. Process the verbal instruction and practical demonstration given.
5. Retain all the detail of the technique taught.
6. Translate it into their own manual techniques.
7. Apply the techniques with precision and consistency.
8. Commit to it twice every day throughout the rest of their life.

Hence, I see that the patient sentiment with current brushes in addressing these sites is:

- Awkwardness when brushing the exposed mesial and distal sites at home.
- Feeling foolish at not being able to do what they were taught.
- Being patronised upon review and the technique is reiterated or "encouraged".
- Disappointed at their professional advising an unrealistic technique.
- Resignation that there is no other option.
- Ultimately, disheartened at being out of control of the problem.

Designing a Solution

To address these issues, in my opinion, the direct benefits of a new type of toothbrush should include the following:

- Intuitive - patient ergonomics and spatial awareness should be placed at the centre of the design so that almost no 'tuition' is required.
- Forgiving technique - brushing motion in different directions should remove plaque.
- Cleaning performance - brush head respecting anatomy and bristles with dynamic performance at the tooth surface.
- Clinical outcomes - reduce gingivitis, enamel and root caries, sensitivity and erosion.
- Gentle on tissues - preserve hard and soft tissues.
- Reach all tooth positions in the mouth - minimise the number of brushes stocked by the user.
- Accessible for all populations - to be available at an affordable price point.
- Longevity - minimise waste and offer lasting performance.
- Environmental sustainability - to be made as recyclable as possible.

Therefore, the design features to account for the above would include the following:

1. Bristles angled so that with natural brushing motions, users would automatically achieve the Bass Technique on these tooth surfaces.
2. Double sided, to face the mesial or distal sites adjacent to an edentulous space.
3. To have an alveolar "bumper"- a rest area to place upon the alveolus offering a positive seating feeling for the user (Fig.8).
4. A concave bristle tip profile to pair up against the convexity of the exposed mesial or distal surface (Fig.9).

Figure 8: **Bass angle automatic, double-sided head**

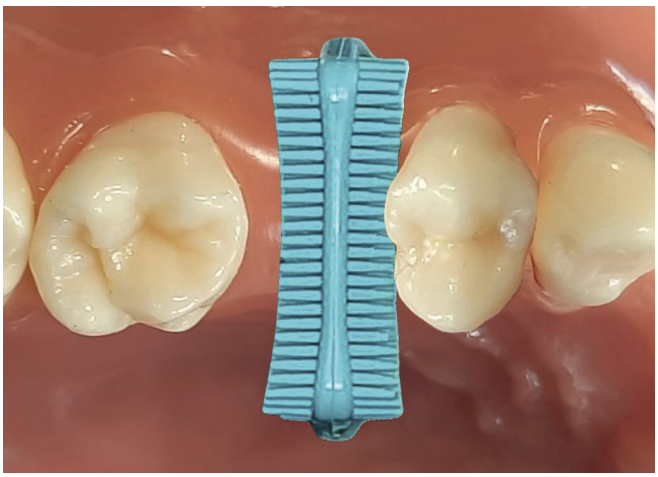


Figure 9: **Concave profile paired to convex tooth surface – horizontal plane**

Figure 10: **Concave brush head paired to convex alveolus – vertical plane**

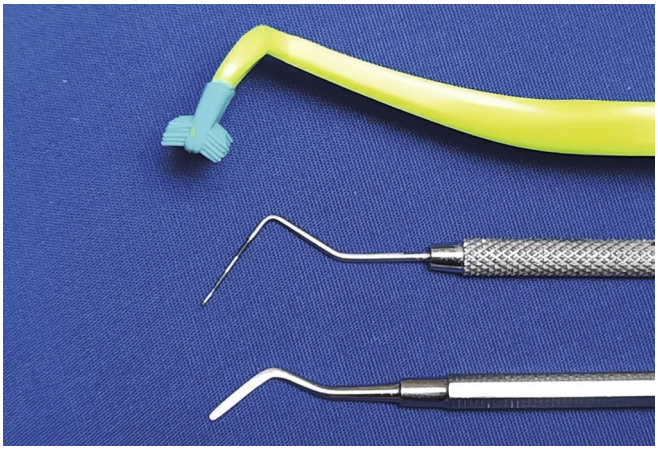
5. A bilaterally supported and concave brush head to allow the application of a consistent pressure of bristles against the tooth throughout the brushing motion and to pair with the convexity of the alveolus (Fig.10).

6. Positioning of the brush head at the end of the long axis of the handle, as in our surgical instruments, allowing ultimate control and the placement of pressure exactly at the working end of the product (Fig.11).

7. An extra wide thumb grip for ergonomics and easy gripping for all types of users. It would also counter torquing forces during lateral brushing motions, increasing tactile feedback and efficiency (Fig.12).

8. Overload mitigation features including elastomer bristles and a flexible brush head.

9. Detachable brush head for easy recycling.



Figures 11: **Brush head at end of long axis**

Figure 12: **Ergonomic thumb grips**

Innovation

With input from numerous dental hygienists, we designed and engineered the ErgoProx incorporating all the necessary criteria. From our UK-based manufacturing hub, we launched Version 1 in 2023, becoming Finalist in FMC New Product of the Year Award.

The response was most favourable from BSDHT members: the vast majority told us that the ErgoProx brush reduced bleeding on probing in their patients at relevant sites. Version 2 launched recently reaching plaque even more effectively – new data to be released soon.

Figure 13: **Single tooth space**

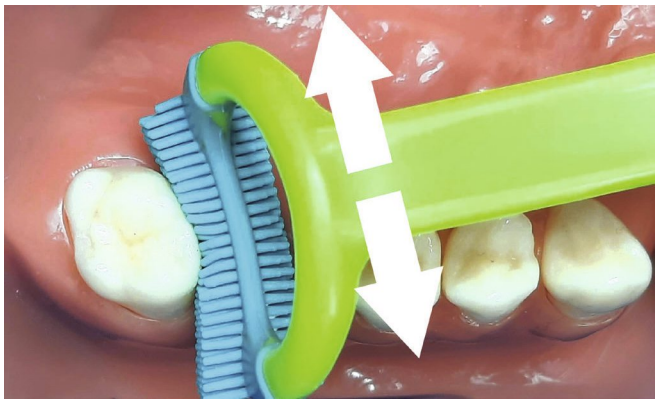


Figure 14: **Simple technique**

Figure 15: **Reaching distal surface**

The ErgoProx brush is 94% recyclable - simply by snipping off the brush head and using domestic recycling for the handle. With patent filings in US, EU, and China, it is the world's first product dedicated for after the extraction of a tooth or at the fitting of partial dentures – addressing the issue before a domino effect of disease can ensue.

Hopefully, our profession will now feel able to empower their patients and conquer what is possibly the final frontier in oral disease prevention at home. Just get in touch for your free sample.

Author:
Michael qualified in 2003 and is a GDP in private practice, Edinburgh. His passion for challenging the status quo in prevention, engineering and ergonomics led him to create the ErgoProx brush. He welcomes collaboration with fellow dental professionals to join him in this global cause.

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