GINGIVAL CREVICULAR FLUID FLOW (VOLUME) AS A BIOMARKER OF ORTHODONTIC TOOTH MOVEMENT

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OBJECTIVE

Orthodontic tooth movement (OTM) leads to remodeling of the periodontal ligament, alveolar bone, and gingiva. Tooth movement is characterized by bone deposition at sites of tension and bone resorption at pressure sites (Fig. 1). Due to a sterile inflammatory process in the periodontal ligament (PDL) space, a flow rate of gingival crevicular fluid (GCF) is increased and its composition is modified (Fig. 2). Various cell signaling pathways are activated, which ultimately stimulate PDL turnover, as well as localized bone resorption and bone deposition (Fig. 3). Processes associated with tooth movement may also be better understood through the study of the GCF flow/volume formed in response to such movement. This information could be used clinically to choose a proper mechanical loading, to improve and to shorten a period of treatment, or to avoid adverse consequences, such as root resorption. Our goal is to monitor changes of GCF flow during orthodontic treatment with Invisalign.

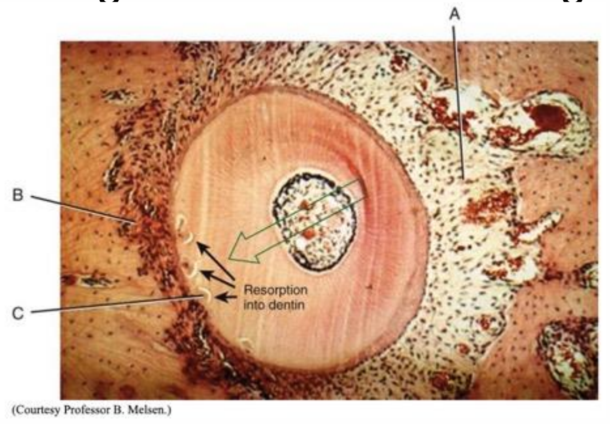

Figure 1. Coronal section through the root of a premolar being moved to the left (arrow). This image shows reactions of tissues in PDL space to application of force. The tension zone (A) is wide, strings of osteoblasts are visible reflecting proliferation and migration of osteoblasts, blood vessels are enlarged, the compression zone (B) is narrow, with packed cells and hardly visible blood vessels, lacunae formed by osteoclasts are visible in the alveolar bone, even lacunae in the root surface are seen (C). *(Proffit et al. 2018)*

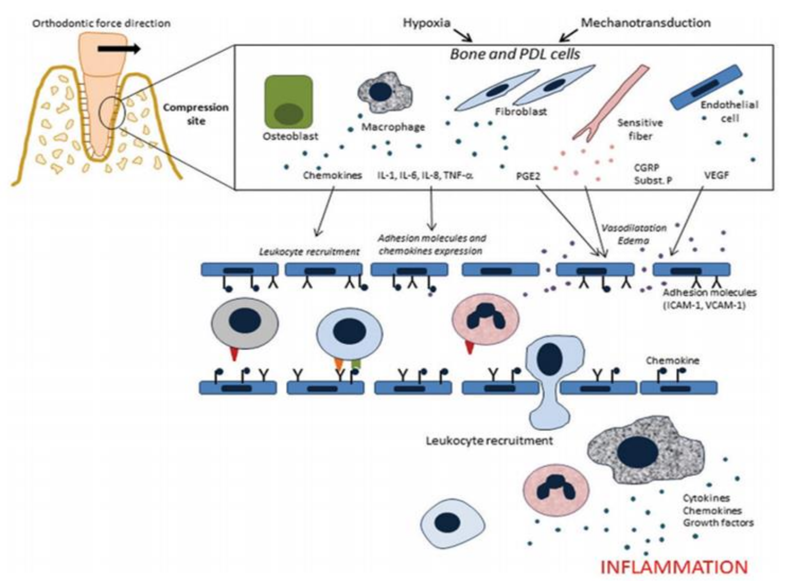

Figure 2 . Inflammatory response of PDL and innate immune system to movement of a tooth. (Andrade, et al., 2012)

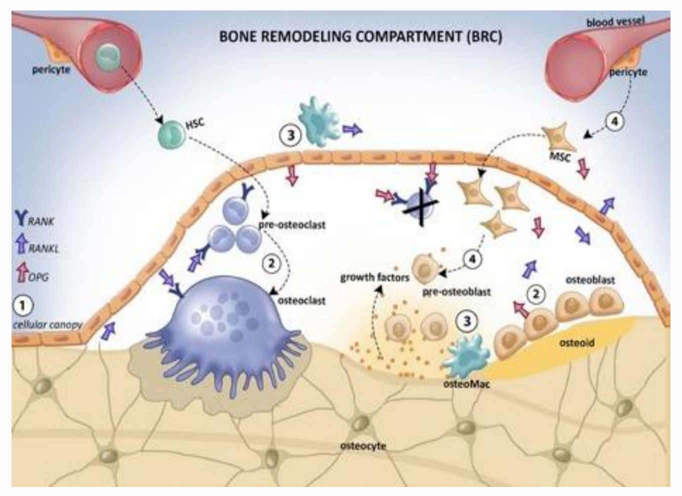

Figure 3. Diagram of bone remodeling. (1) bone that is not remodeled, (2 on the left side) monocytes are attracted into the active remodeling zone and differentiate into osteoclasts, (3) local macrophages digest bone osteoid and release growth factors that were embedded in it, (4) pericytes are the source of new osteoblasts that are triggered by growth factors to proliferate, differentiate and form a new osteoid (2 on the right side). *(Matsumoto et al, 2016).*

METHODS

Various original studies and systematic reviews were focused on identification of GCF biomarkers and their roles during orthodontic treatment. GCF has been extensively studied because of the simple, quick, noninvasive nature of its collection and ease of repetitive sampling from the same site with the help of Periopaper strips (Oraflow) or micropipettes. GCF is analyzed for the content of various biochemical markers and its volume. We collected GCF (IRB #2021-61) into a Periopaper strip positioned in gingival sulcus for 20 seconds (Fig. 4) and measured its volume using Periotron 8010 (Oraflow).

Figure 4 : Periopaper strip in gingival sulcus

RESULTS

Graphs represent the GCF volumes collected from three subjects (Figs. 5, 6, 7). The curves were grouped in respect to different types of teeth involved.

Three general trends can be seen: the curves for teeth of the same type seem to have a similar shape, the curves for one type of tooth seem to differ from the curves of another type, and those curves differed between the three patients.

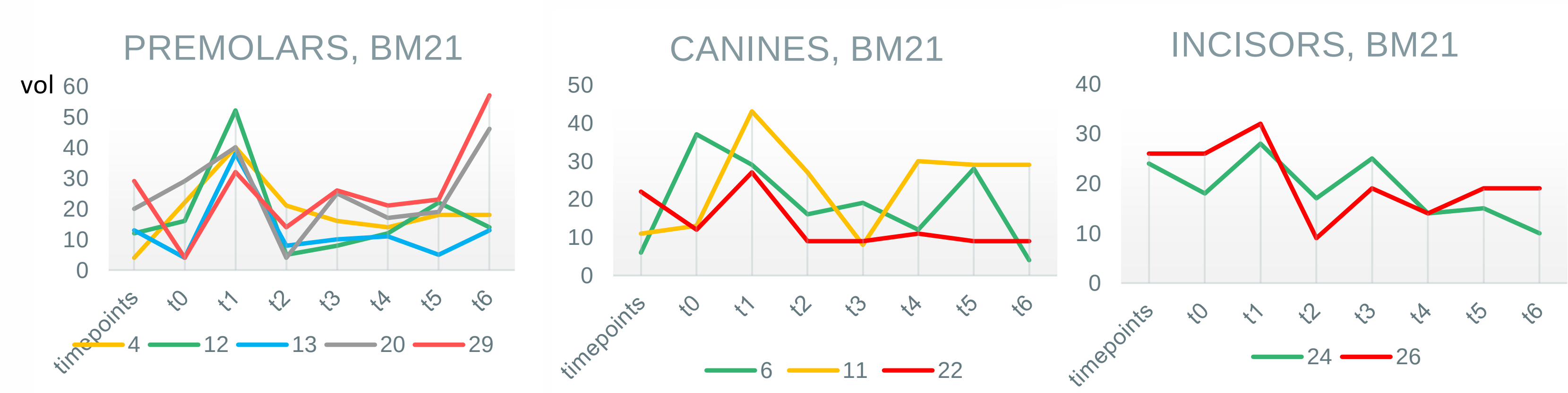

Figure 5. GCF volume curves of premolars (4, 12, 13, 20, 29), canines (6, 11, 22) and incisors (24, 26) of patient BM21. Timepoints t0 (baseline), t1-t2 first aligner, t3-t4 second aligner, t5-t6 third aligner.

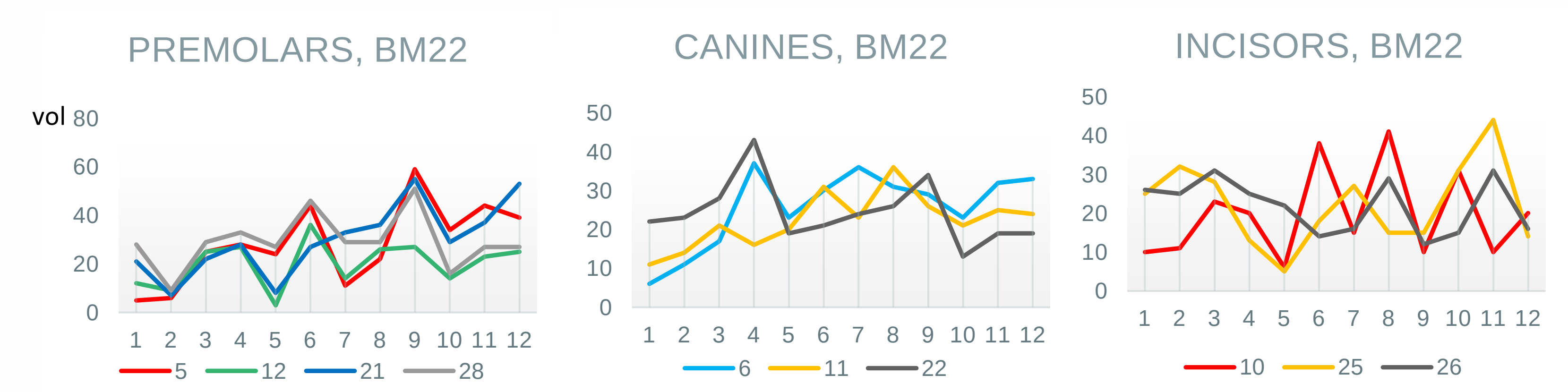

Figure 6. GCF volume curves of premolars (5, 12, 21, 28), canines (6, 11, 22) and incisors (10, 25, 26) of patient BM22. Timepoints 1 (baseline), 2-3 first aligner, 4-5 second aligner, 6-7 third aligner.

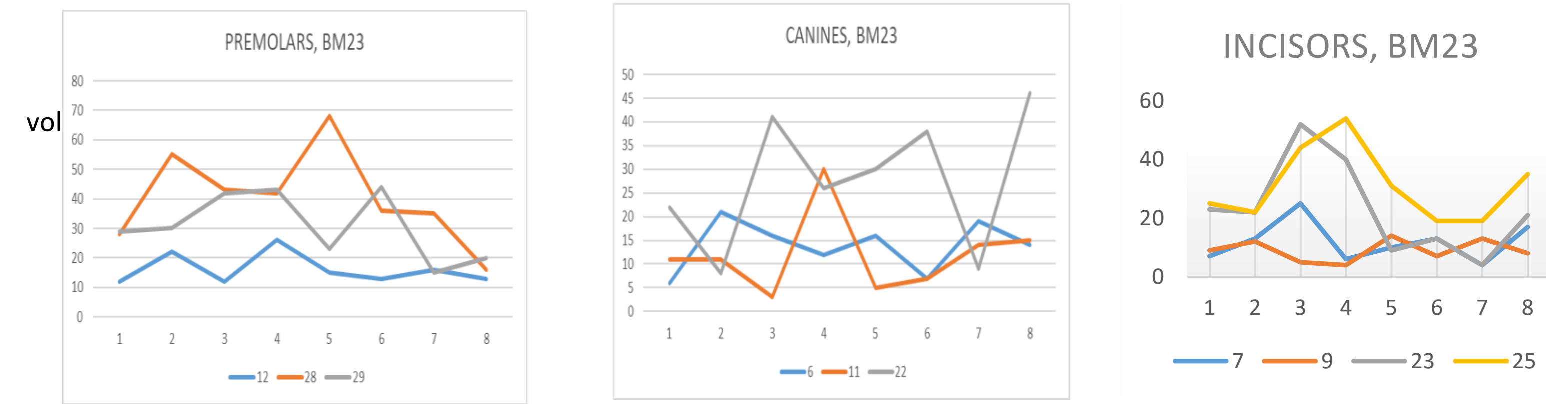

Figure 7. GCF volume curves of premolars (12, 28, 29), canines (6, 11, 22) and incisors (7, 9, 23, 25) of patient BM23. Timepoints 1 (baseline), 2-3 first aligner, 4-5 second aligner, 6-7 third aligner.

CONCLUSION

Real-time studies of ongoing processes in periodontal tissues during orthodontic treatment can lead to a proper choice of mechanical loading, shortening of treatment, better planning and minimizing adverse consequences. Our results seem to suggest that GCF volume could be used as a potential biomarker for such decisions.

However, future research is needed to quantify tooth movement in three-dimensional PDL space, standardize this movement across teeth of different sizes, and more accurately quantify response of periodontal biomarkers in relation to orthodontic force applied during the treatment.

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