

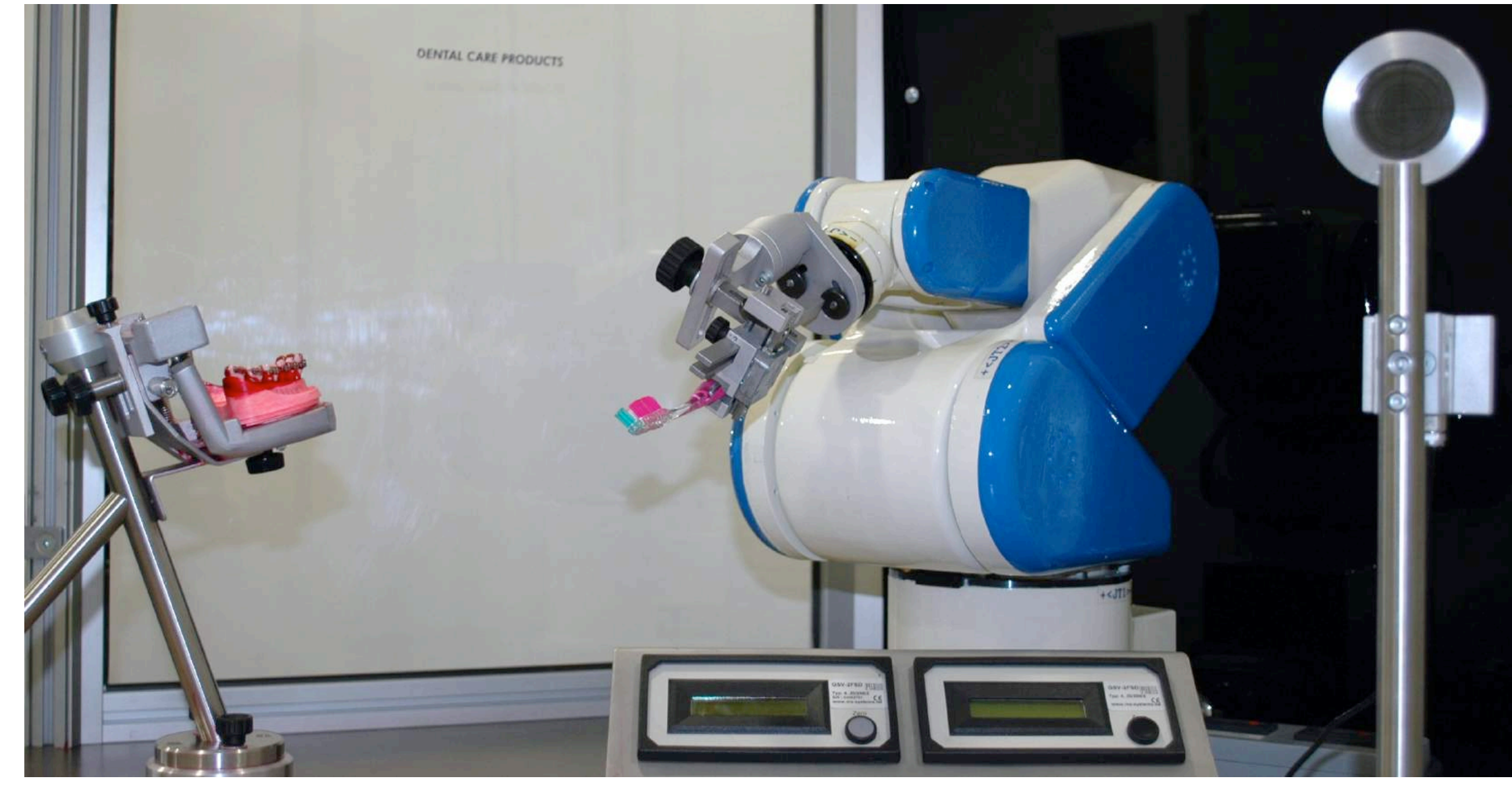
Assessment of Plaque Removal Efficiency by Robot Simulation of Tooth Brushing Poster #: 2514



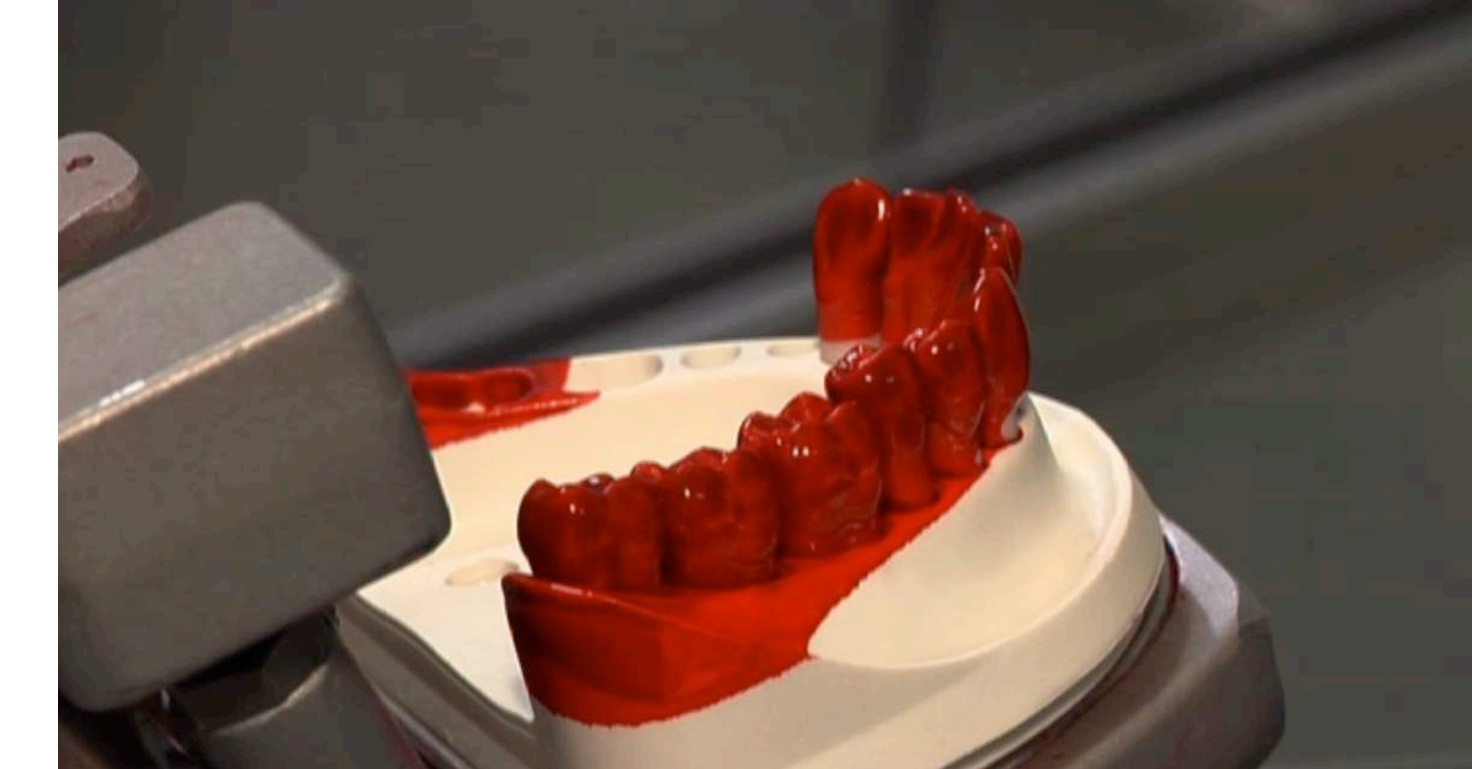
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Objectives:

New toothbrush models and their plaque removal efficiency need to be tested. In vitro tests developed so far do not reproduce the assessed clinical situation. It was, therefore, the aim to transfer a standard clinical tooth brushing programme to a simulated robot brushing programme and to validate the outcome.



Robot setup

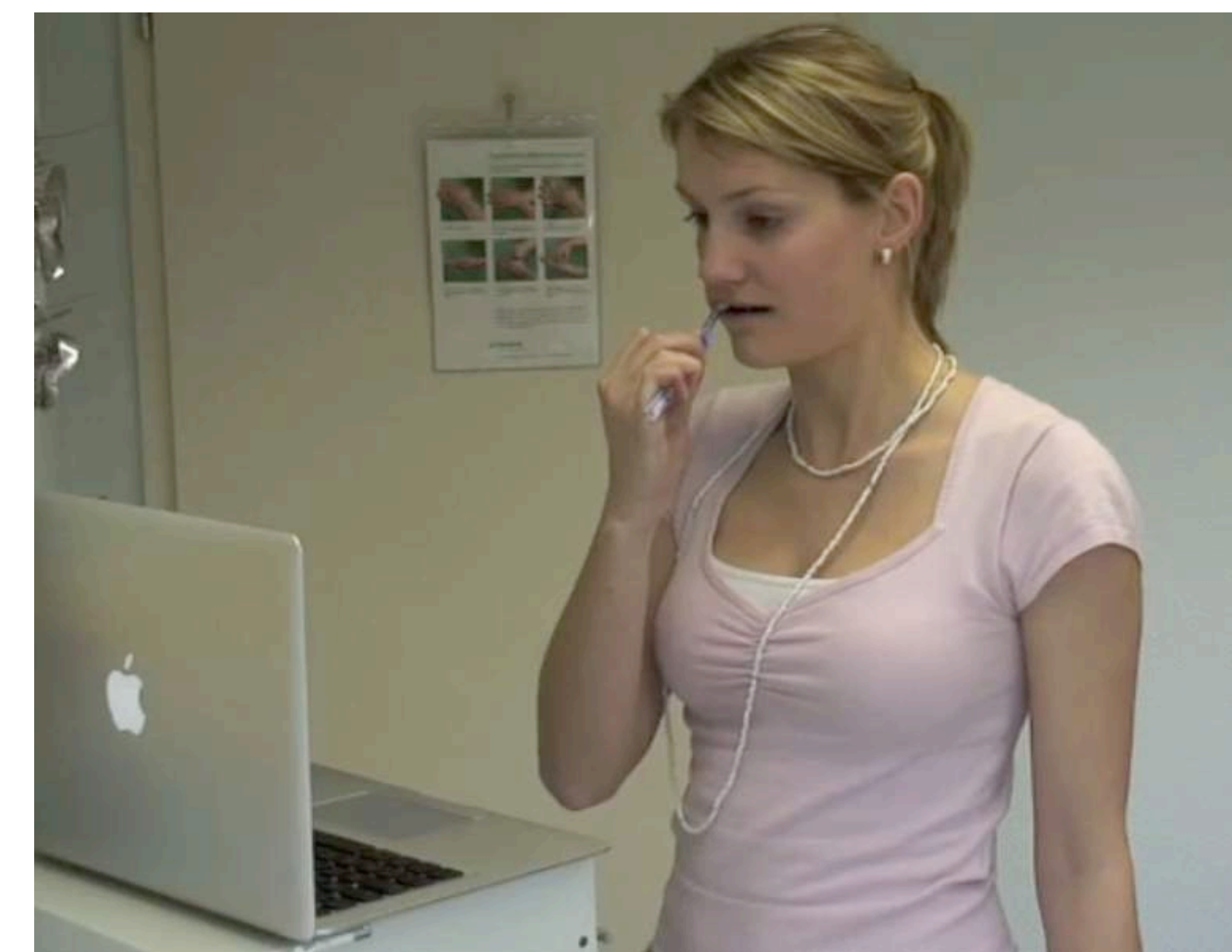


Artificial teeth (KaVo, Germany), stained and mounted for robot simulation

Methods:

Clinical programme:

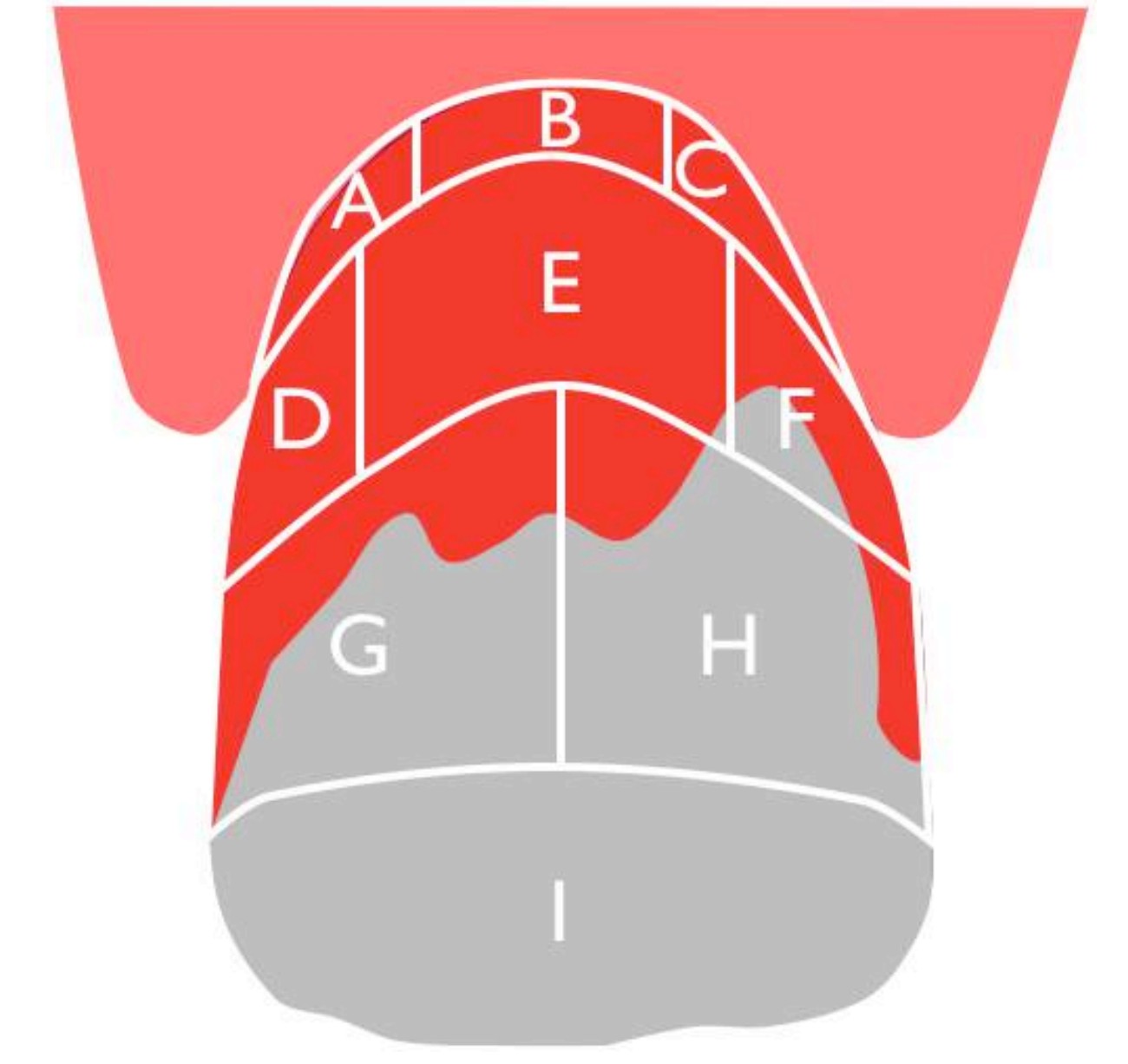
27 well trained subjects (12 male, 15 female) received a professional dental cleaning prior to a 3-day plaque regrowth interval. Plaque was stained, photographically documented and scored before and after tooth brushing using planimetric index (Claydon and Addy 1995). The subjects brushed teeth 33-47 with three most recommended brushing techniques (horizontal, rotating, vertical), each for 20s buccally and for 20s orally in 3 consecutive intervals. The pressure was calibrated (3.5 N) and the brushing technique was video supported. Two brushes with flat trim and interdental cut were compared: Dr.Best@plus medium (n=13) and Dr.Best@Interdent medium (n=14) (GlaxoSmithKline, Bühl, Germany).



Video supported clinical test environment ensures proper brushing time and brushing technique



Calibration of brushing pressure to 3.5 N



Planimetric areas, code 0 = complete plaque removal, code 1 = incomplete or no plaque removal

Robot programme:

The clinical brushing programmes were meticulously transformed to a 6-axis-robot (Kawasaki Robotics, Japan). The artificial teeth 33-47 (KaVo, Germany) were covered with a plaque simulating substrate. All brushing techniques were repeated 7 times and the results were scored according to clinical planimetry. All data underwent statistical analysis by t-test, U-test and multivariate analysis.



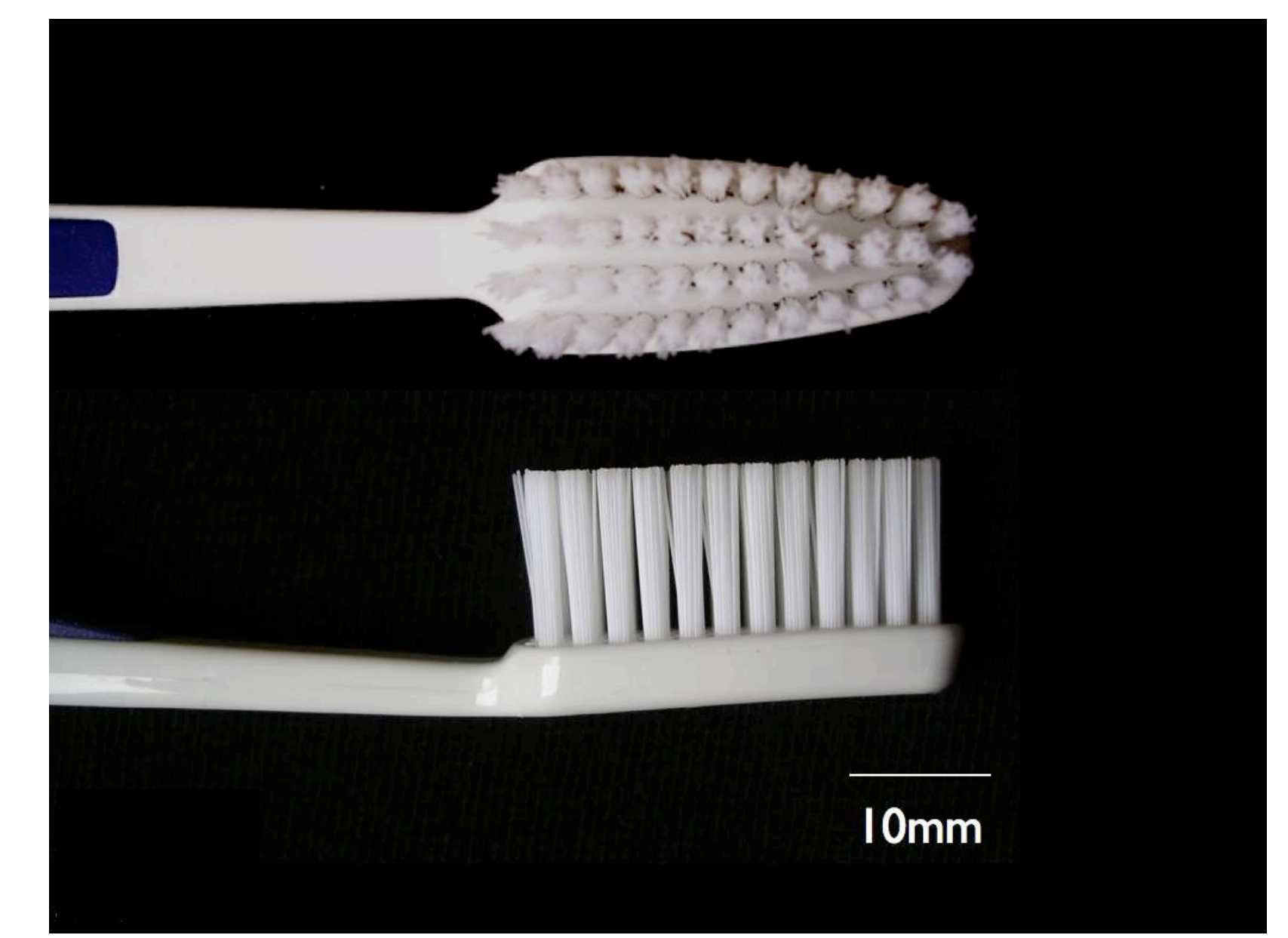
Stained plaque after the 3-day plaque regrowth interval



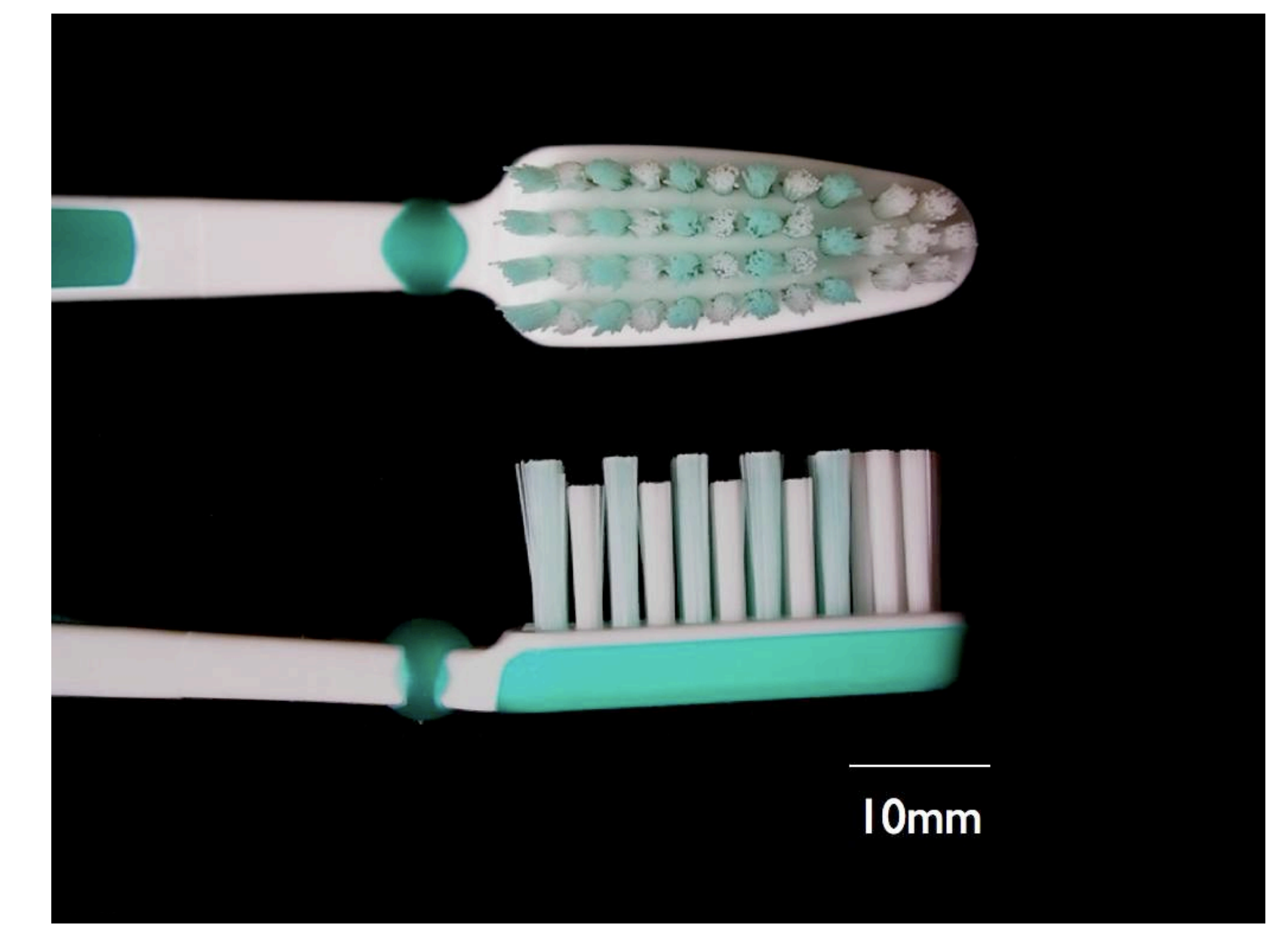
Stained plaque after brushing for 20s



Artificial teeth (KaVo, Germany)



Dr.Best@plus medium



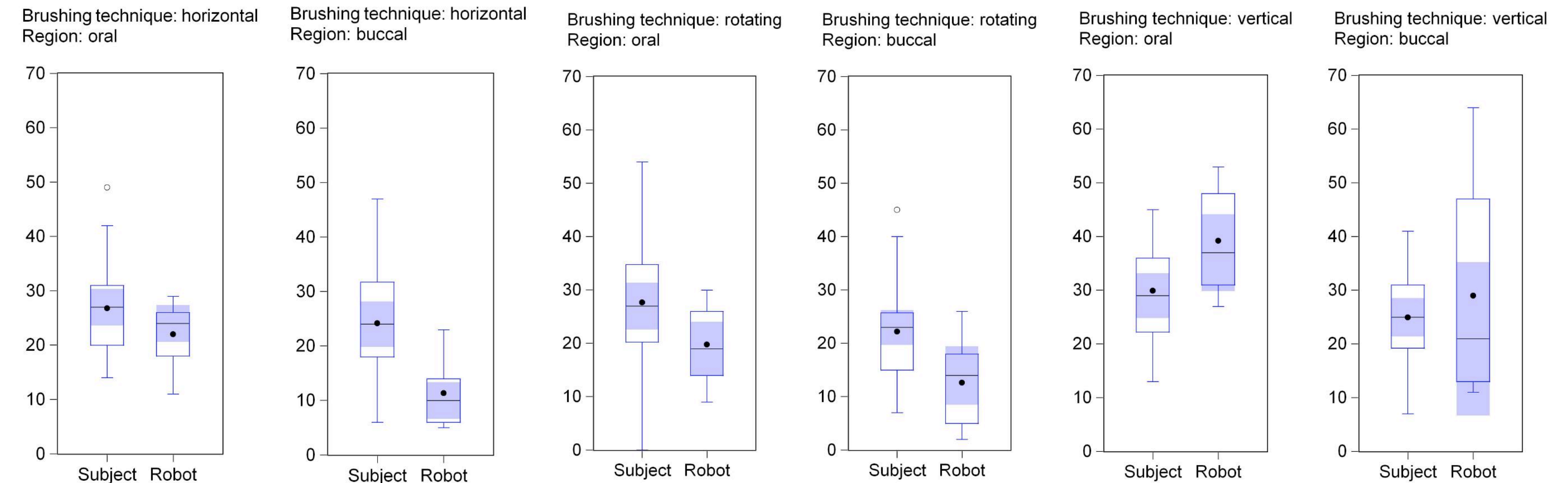
Dr.Best@Interdent medium

Results:

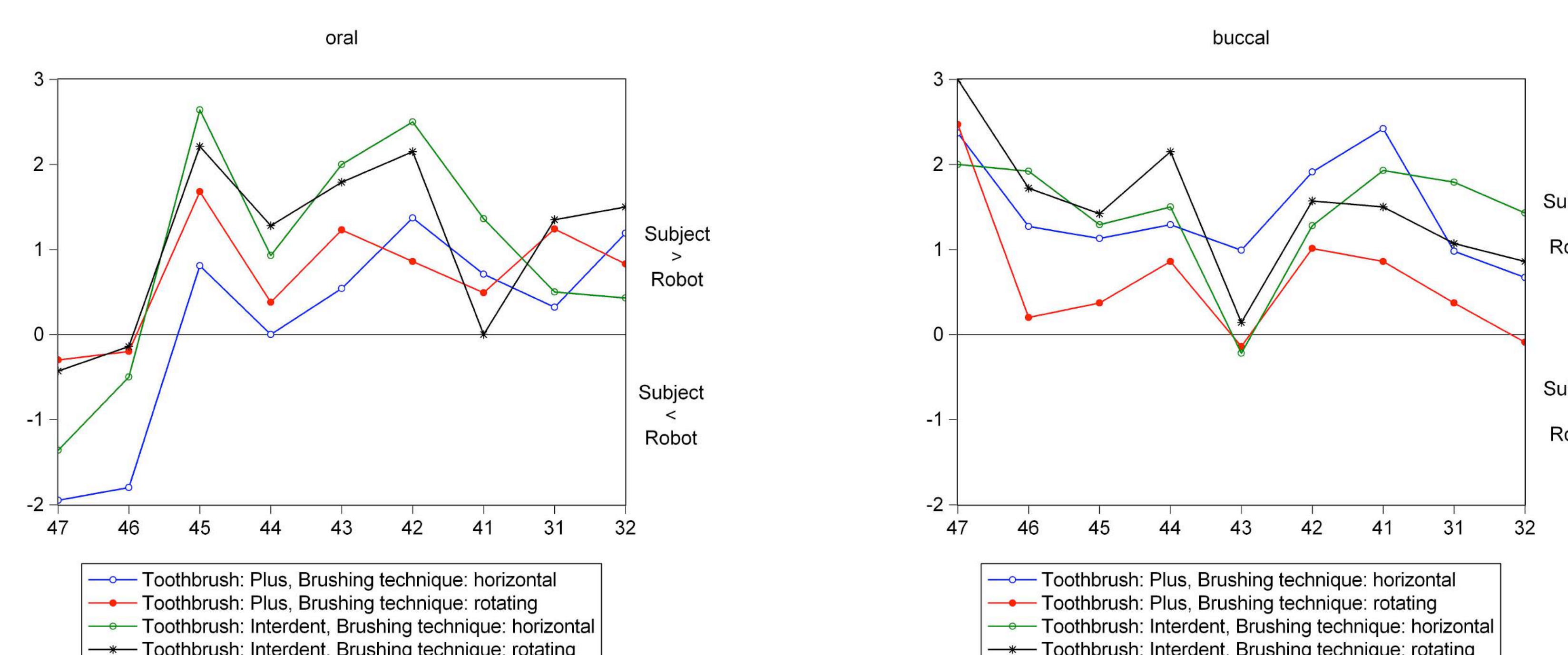
The individual clinical cleaning patterns tooth by tooth as well as the variations of the brushing technique are well reproduced by the robot programmes.

The cleaning efficiency of the robot according to planimetry is in general higher than the cleaning efficiency of the subjects. One exception is the lingual region of tooth 46 and 47 where the cleaning efficiency of the subject was higher than the robot. Differences in plaque removal are statistically significant for the two brushes, for incisors vs. premolars vs. molars and buccally vs. orally. Differences were reproduced in clinical and robot data.

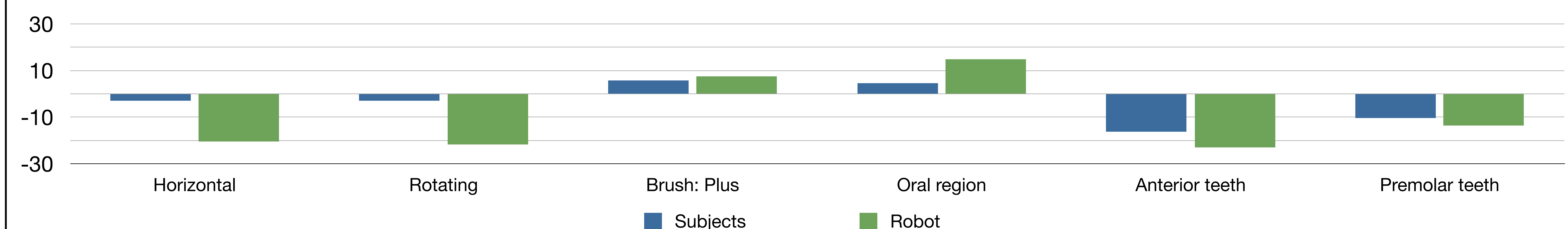
Multivariate analysis confirms the higher cleaning efficiency for anterior teeth and for the buccal sites. Rotating and horizontal technique was superior to vertical brushing. Molars were less effectively cleaned than anterior teeth and premolars. Toothbrush Interdent is superior to toothbrush Plus.



Cumulative number of not completely cleaned planimetric areas of teeth 32-47, both toothbrushes and all subjects and robot cycles



Differences of not cleaned planimetric areas (max.9) in clinical vs. robot tests



Estimated coefficients of multivariate analysis. The following OLS-Regression was estimated:

$$\text{Uncleaned Areas} = C + \pi_1 * \text{Horizontal} + \pi_2 * \text{Rotating} + \pi_3 * \text{BrushPlus} + \pi_4 * \text{Oral} + \pi_5 * \text{Anterior} + \pi_6 * \text{Premolar} + \epsilon$$

Conclusions:

The robot tooth brushing simulation programme showed good correlation with clinically standardized tooth brushing. This new robot brushing simulation programme can be used for rapid, reproducible laboratory testing of tooth cleaning.

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