Computer-assisted Planimetrical Plaque Assessment of Robot Tested Toothbrushing

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Objectives:

A clinically validated robot toothbrushing programme was developed for rapid, reproducible laboratory testing of tooth cleaning (Lang et al. JDR 89 Spec. Iss. B, 2514).
It was, therefore, the aim to supplement the robot test of manual and powered toothbrushes on artificial teeth arranged in adult or mixed dentitions with a computer-assisted photographic documentation system of percentage of plaque removal in 24 planimetrical fields per tooth crown and 4 fields per root.

Methods:

Seven manual toothbrushes (2 soft, 3 interdental cut and 2 kids/junior brushes) underwent horizontal, vertical and rotating brushing movements orally and buccally of teeth 32 – 48.Each run was repeated 5 times. After brushing away the plaque simulating substrate on all teeth, they were transfered to the assessment equipment. The 10 teeth were computer-assisted rotated, so each of the 4 sites was photographed and the percentage of plaque-free area per planimetrical field was assessed. These measurements were repeated 3 times. The plaque assessment programme allows differentiation into 4 surfaces, risk areas like gum line or proximal fields and roots etc. per single tooth or per group of teeth/all teeth. All data underwent statistical analysis (F-test, Kruskal-Wallis test, t-test).
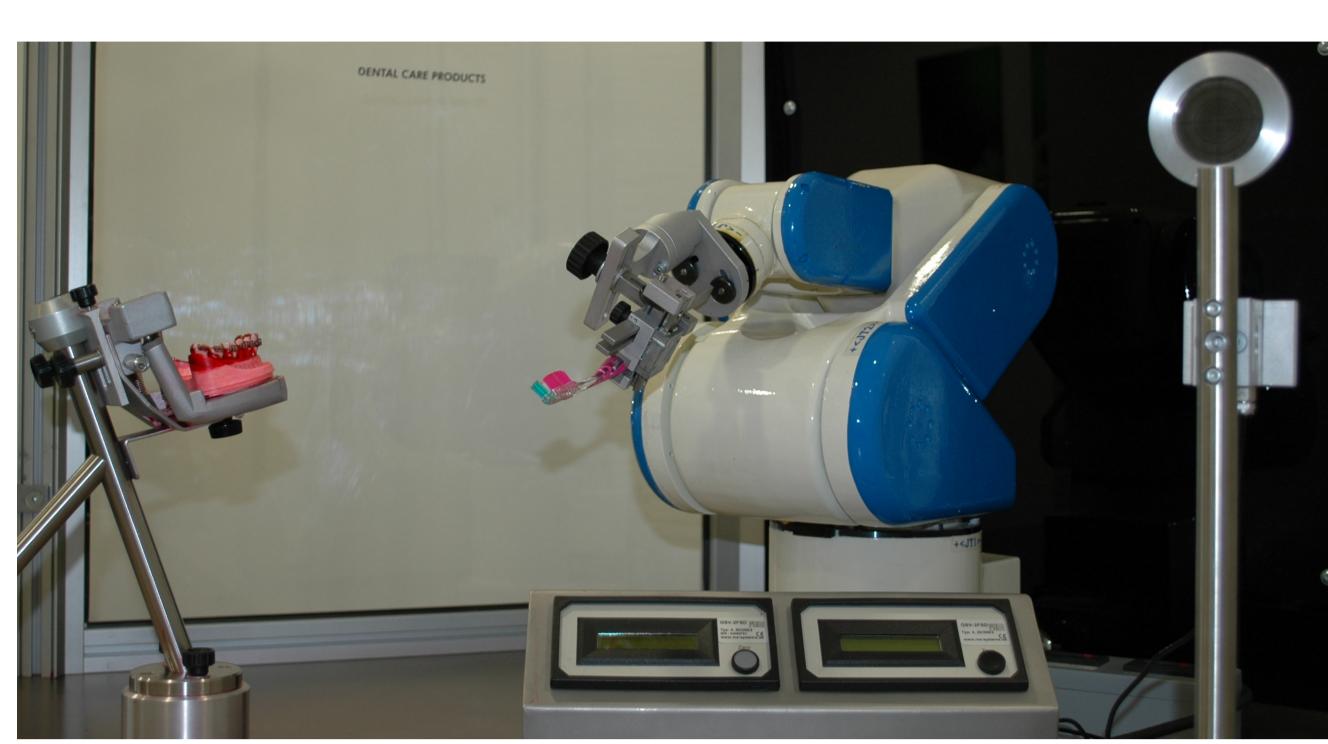
Results:

The plaque removal efficacy of 7 brushes on buccal sites (9 fields) ranged from 37.6% to 83.1%, on oral sites in 9 fields (55.6% - 82.7%), on proximal sites in 3 fields (17.9% - 36.7%) and on in-between surfaces in 5 fields (16.8% - 37.1%). The risk areas next to gum line and proximal fields (ABCDF) exhibited buccally plaque removal efficacy from 19.0% to 59.8% and lingually from 42.5% to 53.1%. Test toothbrushes of different design exhibited extremely and significantly different plaque removal efficacy.
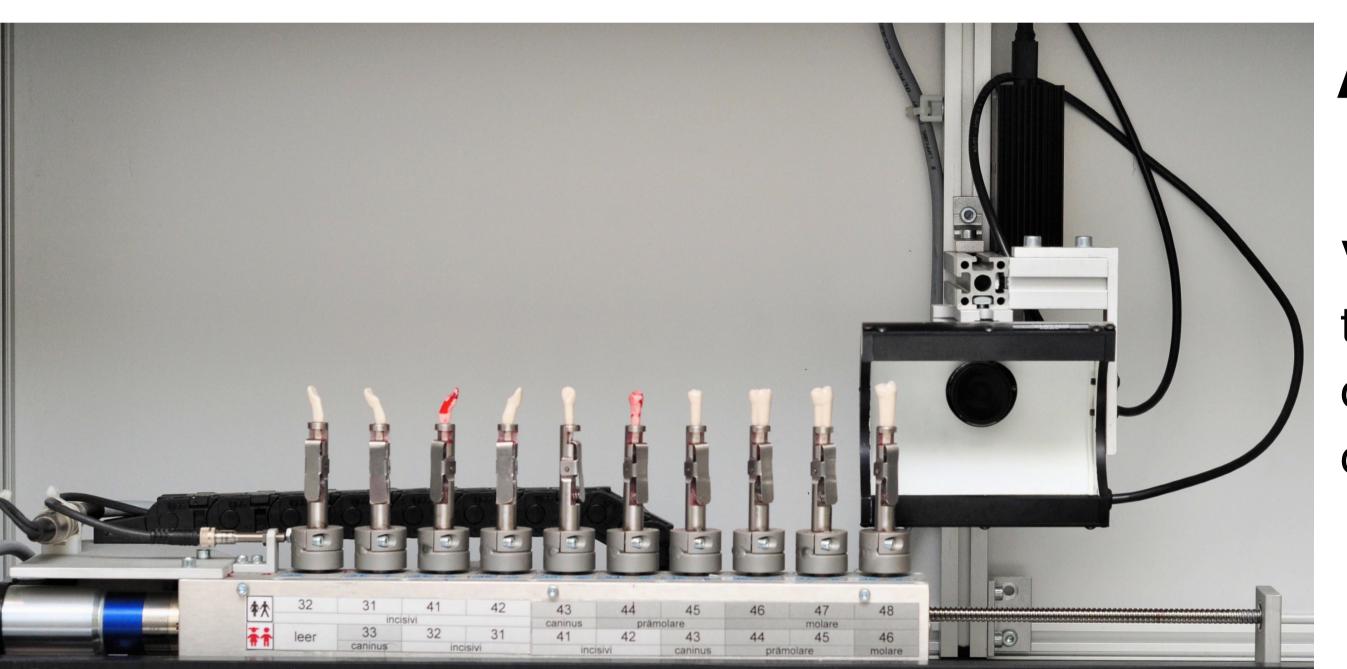
Conclusions:

The planimetrical plaque assessment programme is reproducible and demonstrates the efficacy of test toothbrushes in all planimetrical fields or in any possible combination of fields per tooth, per group or per quadrant of dentition. Robot tested toothbrushing using any brushing technique or any manual or powered toothbrush, supplemented with the computer-assisted planimetrical plaque assesment is a recommended research tool for developing new prototypes and comparisons with reference brushes.

Robot setup

The 6-axis robot can be programmed for any movement of interest of manual or powered toothbrushes. The test toothbrushes a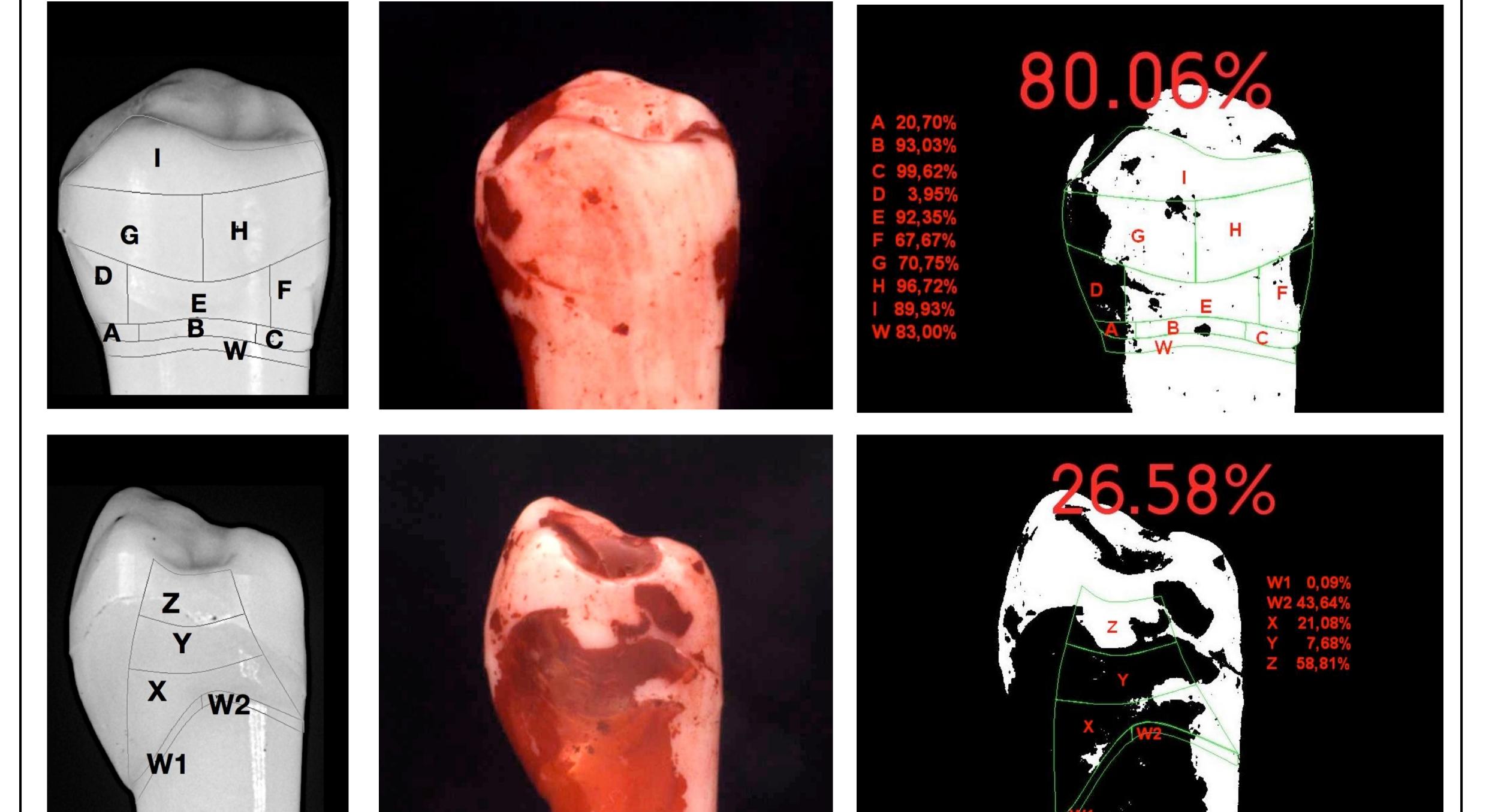re positioned according to the programme, and the brushing force (in Newton) transfered via the brush head is electronically calibrated (right). Brushing takes place in the simulated oral cavity with 4 incisors, 1 canine, 2 premolars and 3 molars (left).

Automated Plaque

View into the black box of site by site rotating test teeth in front of the HD focusing analysis camera, and computer-assisted processing of data.
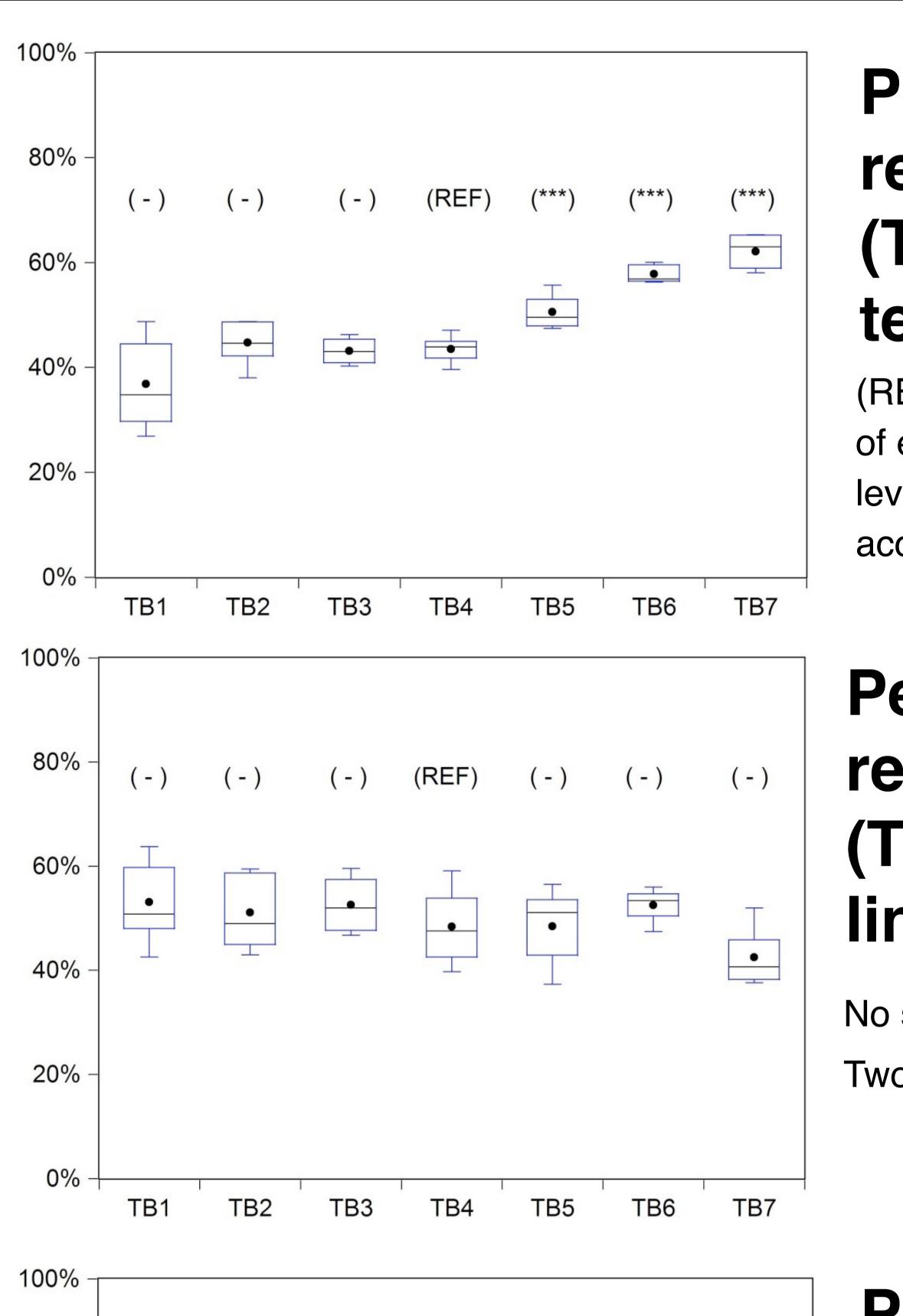

Planimetrical fields

Lingual crown fields (A - I) and one root field (W) on 1. premolar, proximal crown fields (X - Z) and root fields (W1 - W2), same premolar; clinical view of cleaning efficacy, computer-generated total percentage and percentage field by field of cleaning efficacy

Percentage of plaque removal of 7 toothbrushes (TB1-7 total, 4 sites per 10 test teeth)

(REF): Reference toothbrush. The null hypothesis of equal means can be rejected at a significance level of 5 (**) or 1 (***) percent or has to be accepted(-). Two-sided standard-t-tests.
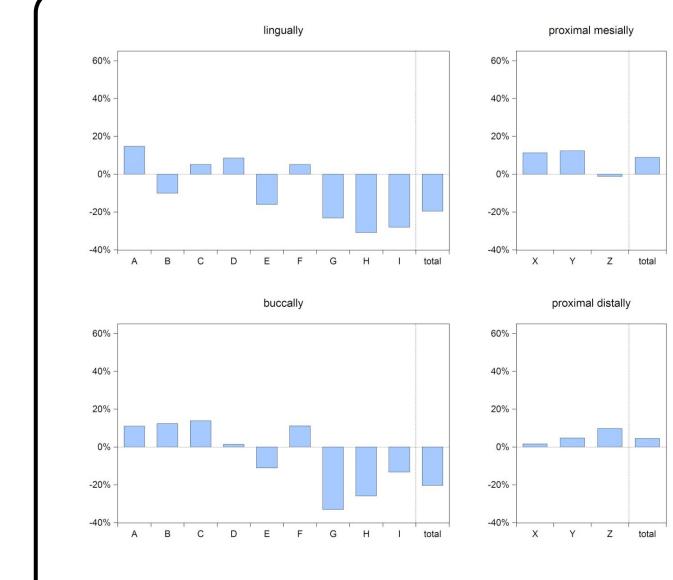
Percentage of plaque removal of 7 toothbrushes (TB1-7, risk fields ABCDF, lingually)

No significant differences.
Two-sided standard-t-tests.

Percentage of plaque removal of 7 toothbrushes (TB1-7, risk fields ABCDF, bucally)

The null hypothesis of equal means can be rejected at a significance level of 1 percent (***) or has to be accepted (-). Two-sided standard-t-tests.
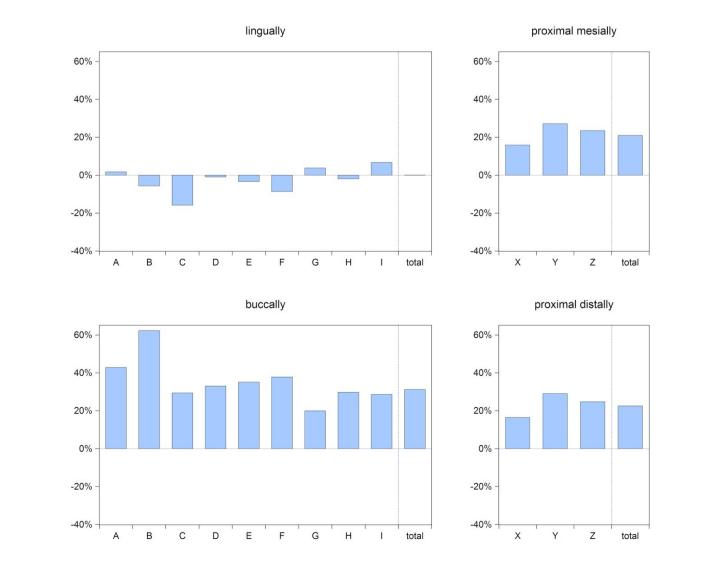
Relative brushing efficacy of toothbrush 1:
Abscissa: Planimetrical fields A-I, X-Z and total site.
Ordinate: Relative plaque removal of toothbrush 1 (= difference between brushing efficacy of toothbrush 1 (in %) and reference toothbrush 4 (in %)).

Relative brushing efficacy of toothbrush 7:
Abscissa: Planimetrical fields A-I, X-Z and total site.
Ordinate: Relative plaque removal of toothbrush 7 (= difference between brushing efficacy of toothbrush 7 (in %) and reference toothbrush 4 (in %)).