Neuroplasticity in the Adaptation to Prosthodontic Treatment

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Aims: *To investigate cerebral cortical changes by using functional magnetic resonance imaging (fMRI) after denture renewal and to test how these relate to prosthodontic treatment adaptability as measured by chewing efficiency and maximum bite force.* ***Methods:*** *Ten complete denture wearers (five women and five men, mean age ± standard deviation: 70.3 ± 9.1 years) participated in the study. Each had their complete dentures renewed and underwent an fMRI examination with three functional tasks (lip pursing; jaw tapping; jaw clenching) as well as a color-mixing test for chewing efficiency and unilateral maximum bite force measurements. Recordings were performed with the old dentures (T0) and with the new dentures on insertion (T1) and at 1 week (T2) and 3 months postinsertion (T3). At T1, denture stability and retention (S/T) were assessed by two independent operators. Wilcoxon signed rank tests and Spearman's rho correlation were carried out for data analysis.* ***Results:*** *The right and the left precentral gyrus (PRCG) and postcentral gyrus (POCG) were identified with significant activation across all three functional tasks. A statistically significant increase in the level of activity between T0 and T2 (POCG:* P = *.022; PRCG:* P = *.017) was found during jaw clenching tasks. Both regions of interest (PRCG, POCG) appeared to correlate with S/T of the new dentures while the subject performed a lip-pursing task (PRCG:* r = *0.689,* P = *.027; POCG:* r = *0.665,* P = *.036). The chewing efficiency and maximum bite force increased significantly during the adaptation to replacement dentures (chewing efficiency: T1-T2* P = *.032, T2-T3* P = *.012; maximum bite force right side: T2-T3* P = *.047).* ***Conclusion:*** *Changes in brain activity occurred in the adaptation to replacement dentures and appeared to regain preinsertion activity levels during motor tasks involving the dental occlusion after 3 months postinsertion.*
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Key words: bite force, chewing efficiency, complete denture; fMRI, neuroplasticity

Prosthodontic treatment aims to improve the quality of life for patients by restoring function and esthetics affected by the loss of one or more teeth. The degree of perceived impairment following tooth loss depends not only on the objective decline of oral function, but is strongly related to the individual's perception of and ability to adapt to the new oral environment. The success of prosthodontic treatment is therefore dependent on the patient's posttreatment adaptation ability, involving sensorimotor changes as well as integration of higher brain-center functions related to past experiences, expectations, and attitudes.

Clinical research in prosthodontics has investigated peripheral sensory and motor changes with different oral rehabilitation modalities. Many studies have investigated oral stereognosis, interocclusal thickness perception, and bite force in dentate and edentulous patients and in those with removable or fixed prostheses for tooth replacement,[1–10] but have not fully explained the large individual variations in adaptation to new appliances. The same treatment modality may be readily accepted by one patient, yet not by another, and there is no reliable clinical test to predict a patient's ability to adapt.

Recent brain imaging studies have begun to focus on changes in regional brain activity related to oral rehabilitation, but there is little information on whether these changes are associated with the adaptation process and/or the treatment success. Different types of prosthodontic rehabilitations were shown to elicit different brain activity patterns.[11,12] The role of neuroplasticity in the adaptation to prosthodontic appliances is still largely unknown and detailed investigations are required.

Maximum Bite Force and Chewing Efficiency in Adaptation

There is evidence that both bite force and chewing efficiency can be considered indicators of a patient's potential for adaptation to prosthodontic treatment. Previous studies have shown that complete denture wearers have a significantly lower chewing efficiency and reduced maximum bite force,[13] as well as smaller chewing cycles[14] and reduced muscle activity,[15] compared to persons with natural dentitions. Limitation in chewing performance with complete dentures is related to mucosal pain threshold, denture stability, and denture retention.[16]

Somatosensory and Motor Cortex Plasticity

Plasticity of somatosensory and motor areas of the cerebral cortex that are related to changes in the sensory afferent input have recently been reported.[17–19] It has been demonstrated that with sensory stimulation alone, measurable changes in motor cortical organization occur and further motor plasticity continues with time, even in old age.[20] Prosthodontic treatment necessarily involves alteration of the oral environment with implant placement, as well as with changes in tooth position, shape of the dental arch, occlusal vertical dimension, and form and fit of dentures. Plasticity is time-dependent and associated with changes in sensory input with modification of motor output to modulate motor skills and fine-motor control.[6,17,21,22] Thus, neuroplastic changes of the oral somatosensory cortex and face primary motor cortex are likely to occur following tooth replacement.

Orofunctional research using blood-oxygen-level–dependent (BOLD) functional magnetic resonance imaging (fMRI) has recently been applied to investigations of orofacial sensorimotor functions. Early studies with fMRI methodology to visualize brain activity during tooth tapping, clenching, and gum-chewing have shown that they activate the sensory, motor, and premotor cortical regions of the brain.[23–25] During chewing, activity was also present in the hippocampus, which suggests a possible role in cognitive or memory functions of aging individuals.[26] Chewing task studies showed age-dependent changes with reduced BOLD signals in the sensorimotor cortex, cerebellum, and thalamus in an older age group.[27] This may be explained by an age-dependent decrease in chewing force and brain neuronal activity.[17,27,28] Soltysik and Hyde recognized the limitation of fMRI in studying task-related jaw movements and demonstrated that a 3-tesla machine and a paradigm with an active task duration between 10 and 14 seconds with motion-sensitive post-processing methods can maximize functional contrast and minimize motion artifacts.[29]

The aim of this study was to investigate cerebral cortical changes by using fMRI after denture renewal and to test how these relate to prosthodontic treatment adaptability as measured by chewing efficiency and maximum bite force. It was hypothesized that adaptability to prosthodontic treatment would be reflected as changes in the sensorimotor cortex.

Materials and Methods

Approval from the Human Research Ethics Committee from Sydney West Area Health Service was obtained (HREC2010/3/4.10[3078] AU RED HREC/09/WMEAD/303). Written and informed consent was obtained from all subjects.

Participants

Eleven complete denture wearers who presented for replacement dentures were recruited, six men (mean age ± standard deviation [SD]: 71.4 ± 4.8 years) and five women (mean age ± SD: 69.2 ± 12.7 years). Study participants were treated between January and July 2010 at the Centre of Oral Health, Westmead Hospital, Sydney, Australia. Dentures were manufactured by different clinicians according to the Hospital's protocol. All prostheses had resin teeth in balanced occlusion and a freeway space avoiding occlusal contact during speech. Participants had been fully edentulous for 22.9 ± 13.4 years.

One male subject did not complete fMRI and hence data from 10 participants were analyzed. Exclusion criteria comprised cognitive impairment and depression, as verified by a Mini Mental State Examination (MMSE)[30] and a Geriatric Depression Scale (GDS).[31]

fMRI Recordings

Magnetic resonance imaging was performed using a 3.0 T GE HDx Twinspeed magnet system (GE Medical Systems) and an 8-channel head coil. Images for each functional task were acquired using echo planar imaging (EPI) MRI sequence with the following parameters: repetition time (TR) = 4,000 ms; TE = 35 ms; matrix = 96 × 96; field of view (FOV) = 24 cm; flip angle = 90 degrees; number of excitations (NEX) = 1. A total of 40 contiguous axial/oblique slices (parallel to the anterior commissure–posterior commissure [AC-PC] line) with slice thickness of 4 mm were acquired to cover the whole brain in each volume. For each activation task, 50 volumes were collected with a scan time of 3 minutes 32 seconds. Three initial "dummy" volumes were acquired within each sequence to ensure BOLD saturation. Structural MRI 3D T1-weighted images were acquired in the sagittal plane by using a 3D spoiled gradient recalled (SPGR) sequence (TR = 8.3 ms; TE = 3.2 ms; flip angle = 11 degrees; inversion time [TI] = 500 ms; NEX = 1; array spatial sensitivity encoding technique [ASSET] = 1.5; frequency direction: superior/inferior [S/I]). A total of 180 contiguous 1-mm slices were acquired that covered the whole brain with a 256 × 256 matrix with an in-plane resolution of 1 × 1 mm resulting in 1 mm^3 isotropic voxels. The 3D SPGR sequence was collected for use in unified segmentation approach for normalization of the fMRI data to standard space.

Chewing Efficiency

To assess the chewing efficiency, a two-color mixing-ability test was used as described previously by Schimmel et al.[32] Specimens were prepared from "Hubba-Bubba" Tape Gum (The Wrigley Company Ltd) in the flavors "Sour Berry" (azure color) and "Fancy Fruit" (pink color). Strips 30 mm long were cut from both colors and manually pressed together, so that the test strip dimension was 30 × 18 × 3 mm. The subjects were asked to chew one sample of gum on their preferred chewing side for 20 cycles and to expectorate the bolus into a transparent plastic bag. The specimens were then flattened to a wafer of 1 mm thickness and scanned from both sides with a resolution of 500 dots per inch (dpi). The scanned image was resized (1,175 × 925 pixels) and stored in Adobe Photoshop format. As a reference scale, a scanned piece of unmixed gum was copied in each image (area of 4,779 pixels). The "magic wand" tool was used (tolerances 20, 25, 30; Photoshop) to select the unmixed azure parts of the image, and the numbers of selected pixels were recorded from the histogram; the unmixed fraction (UF) was calculated according to the following formula:

$$\frac{(\text{mean of Pixels azure scan side a} + \text{mean of Pixels azure scan side b}) - 2 \times \text{Pixels of scale}}{2 \times \text{Pixels all}}$$

UF shows a strong logarithmic association with the number of chewing cycles[33] and is therefore an inverse measure of chewing performance. The inverse measure (1/UF) will increase with increasing color blending and sweetener extraction; both are predictors for chewing efficiency.[34] Thus, the higher the 1/UF, the higher the individual chewing efficiency.

Bite Force

The maximum voluntary bite force was recorded unilaterally in the first molar region by using an occlusal Force-Meter GM 10 (Nagano Keiki Co). The accuracy of this occlusal force gauge had previously been confirmed.[35,36] Before the recording, the subject was seated upright without head support with the Frankfort plane parallel to the floor. The gape with the occlusal force gauge inserted in the molar region was measured with a dental aluminum ruler (Gestenco International AB). Subjects were instructed to bite as hard as possible on the occlusal force gauge without moving the head, and recordings were repeated three times on each side with a 10-second resting time between each bite. The average and the highest values were noted.

Protocol

Functional imaging was performed first with the existing complete dentures in place (time point T0) for all participants. Block design as recommended by Soltysik and Hyde[29] was employed. Each task was practiced before the fMRI recordings. Participants were asked to lie comfortably supine on the scanner table with their head immobilized with foam pads, and earplugs were provided to reduce auditory discomfort. Earphones were worn for communication with the recording team. The task paradigm was an alteration between 20 seconds of active task (on) and 20 seconds of rest in the resting position (off). Subjects received visual instructions through special goggles. This on–off procedure was repeated five

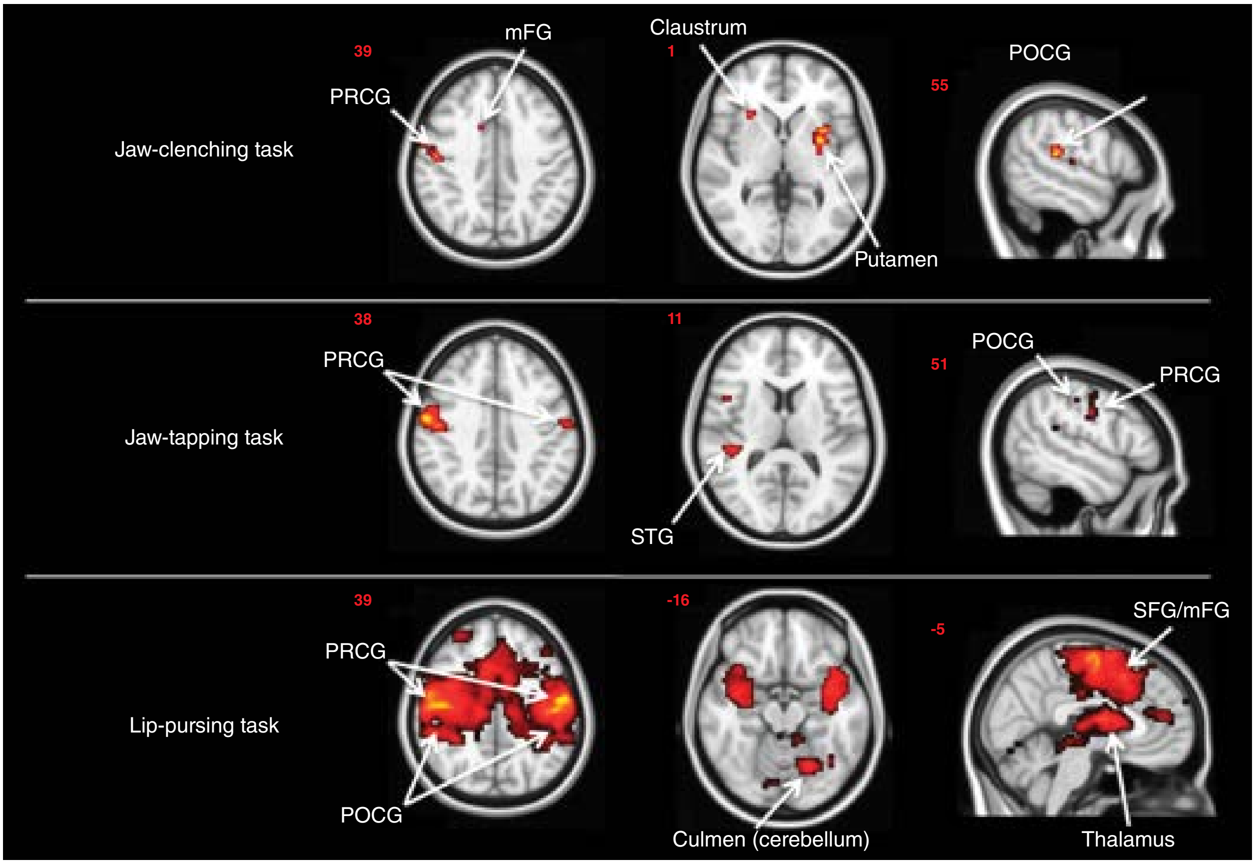


Fig 1 fMRI results from the conjunction analysis showing significant clusters of activations (FWE corrected $P < .05$) for each of the three tasks. (PRCG = precentral gyrus; POCG = postcentral gyrus; mFG = medial frontal gyrus; SFG = superior frontal gyrus; STG = superior temporal gyrus). Activations are overlayed on Montreal Neurological Institute (MNI) space standard anatomical image. MNI space location (in mm) for each shown image slice is indicated in red.

times in five scanning runs, resulting in total task duration of 8 minutes 20 seconds. Three tasks were performed: jaw (tooth) tapping, jaw clenching, and lip pursing. Participants were instructed to tap gently (from resting jaw position without head movement) in a constant rhythm and as fast as possible during the "on" period for jaw tapping; to clench their jaw as hard as possible for 3 seconds and relax during the "on" period for jaw clenching; to push the lips forward like giving a kiss and relax during the "on" period for lip pursing. Following fMRI imaging, chewing efficiency and bite force were recorded.

Following these recordings, replacement dentures were made for each participant according to a standardized protocol. At insertion, the dentures (time point T1) were checked for comfort and assessed by two independent operators for stability and retention (S/T) according to the modified index of Kapur.[37] The fMRI protocol as well as chewing efficiency and bite force tests were repeated on the same day (time point T1). These tests were also repeated after 1 week (time point T2) and 3 months (time point T3) postinsertion.

Data Processing and Statistical Analysis

Preprocessing and statistical analyses of fMRI data were conducted using Statistical Parametric Mapping (SPM-5 Wellcome Department of Neurology, London, UK; www.fil.ion.ucl.ac.uk/spm). Functional scans were realigned, unwrapped, spatially normalized, and smoothed to remove movement artifacts and to place data from different subjects into a common anatomical frame. Images were normalized into standardized Montreal Neurological Institute (MNI) reference space by using a unified segmentation-normalization procedure.[38] In the first-level fixed effect analysis, a hemodynamic response convolved boxcar function was used to model the BOLD response for each task. Contrast images of task vs rest condition were derived for each participant at each time point (T0; T1; T2; T3). The individual contrast images were then entered into a second-level random effects conjunction analysis to identify significant clusters of activity for each of the tasks by using data from all time points.

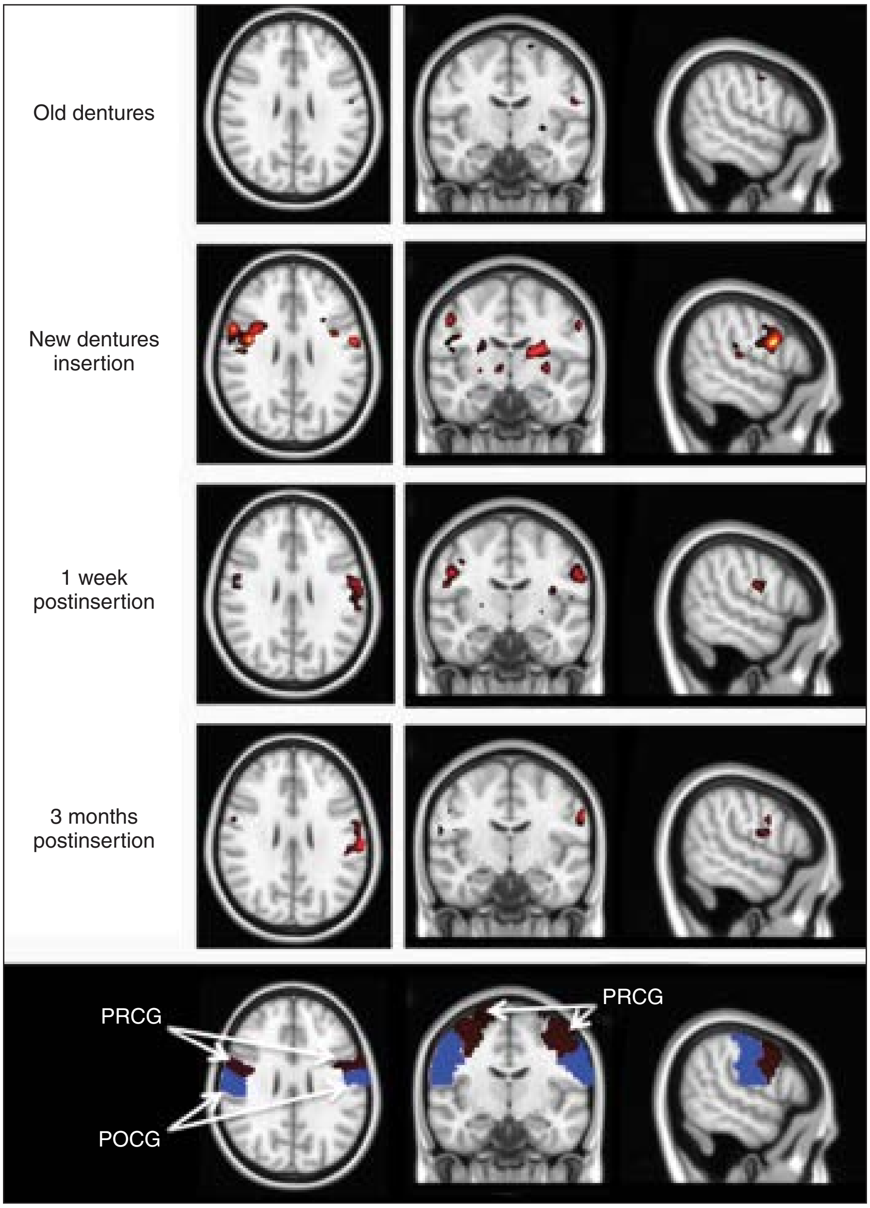


Fig 2 Precentral gyrus (PRCG) and postcentral gyrus (POCG) fMRI activations during jaw-clenching task across the four time points ($P < .001$ uncorrected threshold used for display of activations). The bottom image shows anatomical localization of PRCG (in brown) and POCG (in blue) brain regions.

Significant clusters of activity were determined according to statistical threshold $P < .05$ familywise error (FWE) corrected for multiple comparison. The Talairach atlas was used to label the identified clusters of activity.[39] Post-hoc regions of interests were defined based on findings from the conjunction analysis, and percent of BOLD signal change values for these regions of interest were extracted for each time point. Wilcoxon signed rank tests were used to compare intra-individual paired data across time points, and Spearman's correlation was carried out to explore associations with other variables and to elicit any time dependence. With data on maximum bite force and chewing efficiency, a Wilcoxon signed-rank test was used to determine differences of mean force values and UF score across the times.

Results

Brain Activations for Each fMRI Task

The conjunction fMRI analyses were performed for 10 subjects (Fig 1). With lip pursing there was significant activation in both the left and right hemispheres, showing areas of activity in the frontal and parietal lobes and sublobar region ($P < .05$ FWE corrected). Areas activated included the precentral gyrus (Brodmann Area [BA] 6), the superior frontal gyrus (BA 8), and medial frontal gyrus (BA 8) in the frontal lobe; the postcentral gyrus (BA 3) and the precuneus (BA 7) in the parietal lobe, as well as the thalamus (BA 13) in the sublobar area. The culmen in the anterior lobe, the inferior temporal gyrus

(BA 19), and subgyral (BA 37) region in the temporal lobe were equally activated during the lip-pursing task.

There was also significant activation during jaw clenching in both the left and right hemispheres, particularly in areas in the frontal and parietal lobes and sublobar region ($P < .05$ FWE corrected). Areas activated in the frontal lobe included the precentral gyrus (BA 6 and 4) and medial frontal gyrus (BA 6), the postcentral gyrus (BA 40 and 2) and inferior parietal lobule (BA 40) as well as the claustrum; insula (BA 13), and lentiform nucleus in the sublobar region. The transverse temporal gyrus (BA 41, 42) was activated in the temporal lobe.

For the jaw-tapping task, areas in the frontal lobe in the precentral gyrus (BA 6, 4, and 44), the postcentral gyrus (BA 40 and 2) and inferior parietal lobule (BA 3) in the parietal lobe ($P < .05$ FWE corrected) were activated. In addition, the superior temporal gyrus (BA 13 and 41) in the temporal lobe was activated.

Region of Interest Analyses

From the conjunction analysis, four major areas were identified with significant activation across all three fMRI tasks; these were the right and left precentral gyrus (PRCG) and the right and left postcentral gyrus (POCG). The BOLD signal from these regions was used for all further analyses. A *t* test showed no significant difference between the left and right postcentral and precentral gyrus activity in the three tasks over the observation period, and as a result the BOLD signals were averaged across hemispheres.

Postcentral Gyrus. The postcentral gyrus houses the primary somatosensory cortex including BA 3, 1, and 2. For the postcentral cortex, the only significant difference in BOLD signal between time points was found for the jaw-clenching task. A statistically significant increase was found in the level of activity between the old denture (T0) and after 1 week of wearing the new denture (T2) ($P = .022$). In general, the following pattern was observed: no immediate change (ie, at time point T1), an increase in functional activity 1 week postinsertion of new dentures (T2) and then normalization to the same level as that for old dentures at 3 months postinsertion (T3). This was seen for jaw tapping (Fig 2; Fig 3a) and jaw clenching (Fig 3b). In contrast, for lip pursing the activation pattern was different, with almost no change in functional activity until 1 week postinsertion of new dentures (ie, T0–T2) and then an increase in BOLD signal only after 3 months postinsertion of the new dentures (Fig 3c). The BOLD activity in this region during the lip-pursing task was found to be significantly associated with the stability/retention score (S/T) of the mandibular denture at T1 (POCG vs mandibular denture S/T: $r = 0.665$, $P = .036$) and at trend level significance for the score for the maxillary denture (POCG vs maxillary denture S/T: $r = 0.608$, $P = .062$). An association with sex at T1 indicated that within the sample, the females had greater activation in POCG during the lip-pursing task (POCG vs sex: $r = -.801$, $P = .005$).

Precentral Gyrus. The primary motor cortex including BA 4 and 6 (the supplementary motor cortex) is located in the precentral gyrus. The change in functional activation pattern in the precentral region over time was similar to that seen for the postcentral cortex (Figs 3a to 3c). As above, the significant differences between time points were present only for the jaw-clenching task. There was a significant increase in functional activation for 1 week of wearing the new denture (T2) compared with the level of activation when wearing the old dentures (T0) ($P = .017$) and a trend for increased activation with the new dentures (T1) ($P = .059$).

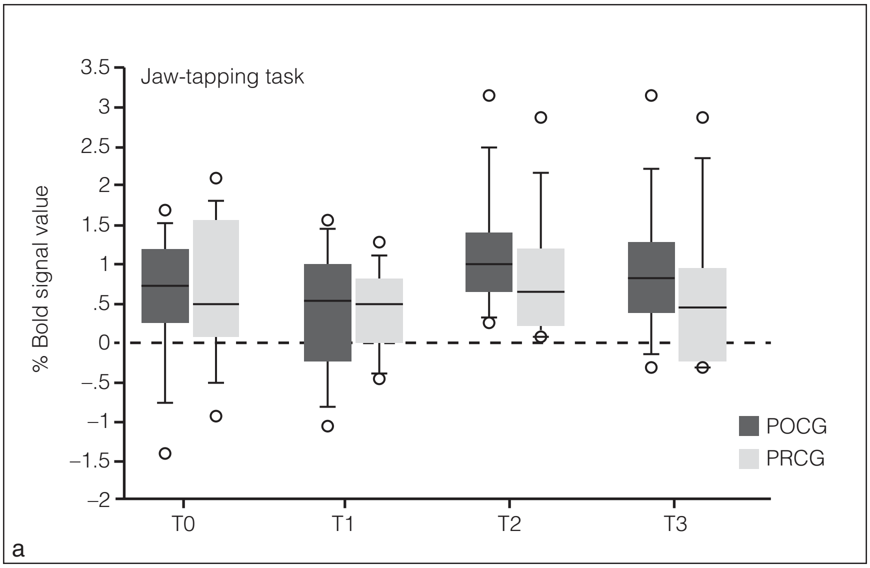
Spearman's rho correlation showed a positive association with % of BOLD activity in the PRCG during the lip-pursing task and the S/T score of the mandibular denture at T1, and trend towards an association with the maxillary denture (PRCG vs mandibular S/T: $r = 0.689$, $P = .027$; PRCG vs maxillary S/T: $r = 0.596$, $P = .069$). Further, there was an association with sex at T1, indicating that females had greater activation in PRCG during the lip pursing (PRCG vs sex: $r = -0.801$, $P = .005$).

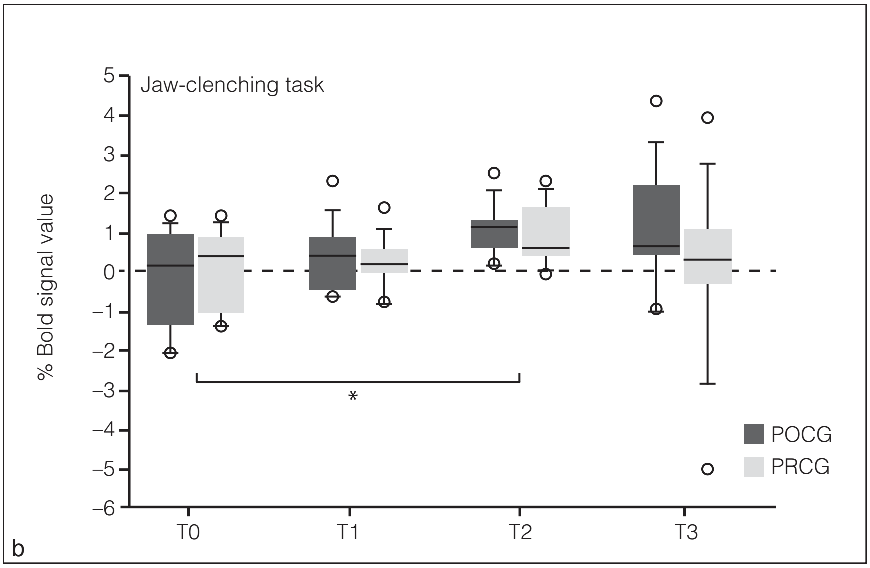
Chewing Efficiency

The chewing efficiency tended to decrease at insertion of the new denture, but subsequently significantly improved during the adaptation period. Although the median chewing efficiency at 3 months postinsertion was better than with the old dentures, but this difference was not statistically significant ($P > .05$).

A Wilcoxon signed rank test revealed a statistically significant increase in chewing efficiency after wearing the new dentures for 1 week ($P = .032$), and this improvement became further evident after 3 months ($P = .012$) (Fig 4a). The change in chewing efficiency between preinsertion and immediate postinsertion approached significance ($P = .050$).

Spearman's rho correlation analysis revealed no correlation between the chewing efficiency, stability, and retention score for the mandibular and maxillary denture and the degree of ridge atrophy.





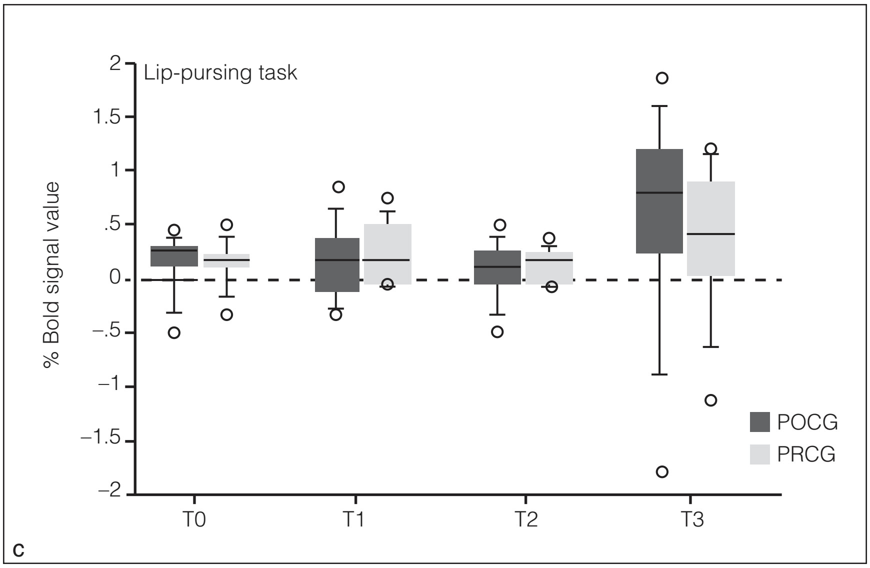


Fig 3 Box-plot (line = median, box = 50% quartile, whiskers = 90% quartile, circles = outliers) of the percentage changes of blood-oxygen level during a particular task for the precentral gyrus (PRCG) and postcentral gyrus (POCG) with the old denture (T0), at insertion (T1), and at 1 week (T2) and 3 months (T3) following denture delivery. Tasks tested were *(a)* jaw tapping, *(b)* jaw clenching, and *(c)* lip pursing. A statistically significant (*) increase was found between T0 and T2 (POCG: $P = .022$; PRCG: $P = .017$) during the jaw-clenching task.

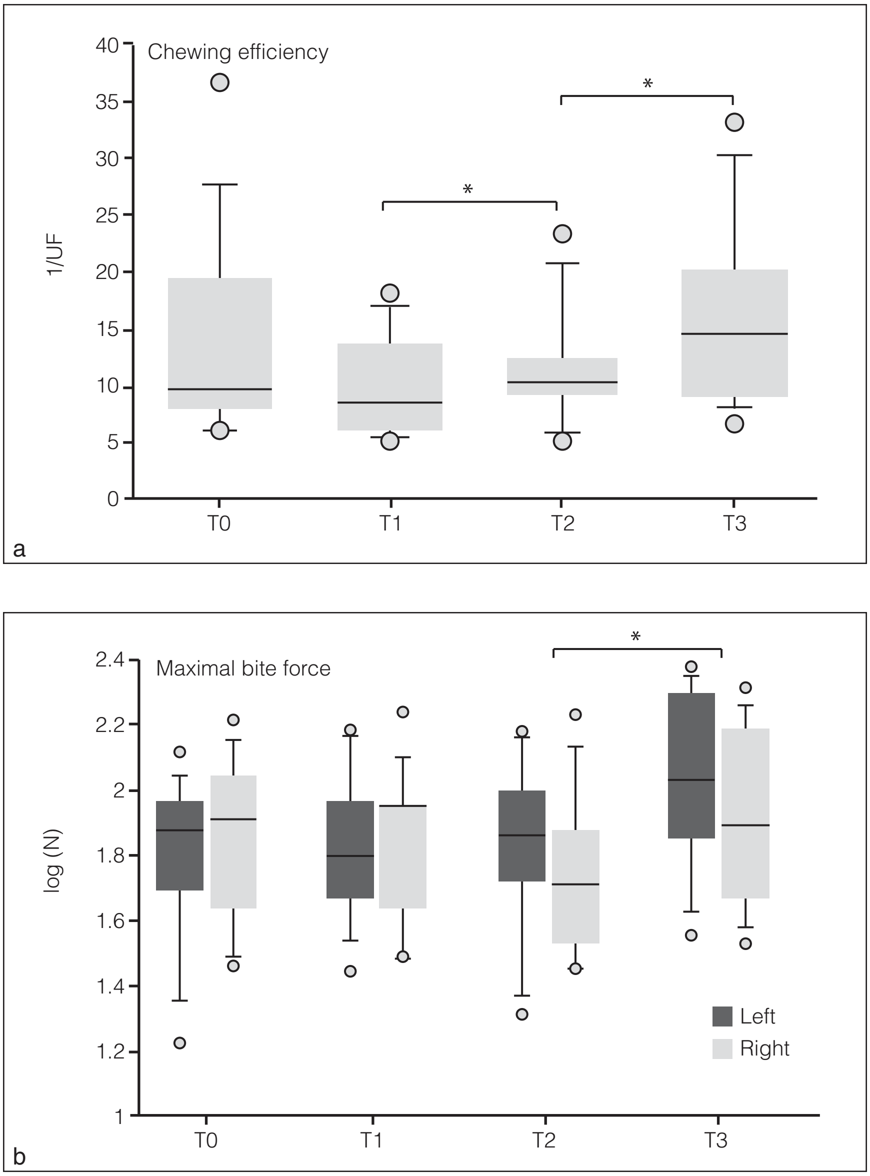


Fig 4 Box-plot (line = median, box = 50% quartile, whiskers = 90% quartile, circles = outliers) of chewing efficiency and maximal bite force with the old denture (T0), at insertion (T1), and at 1 week (T2) and 3 months (T3) following denture delivery. *(a)* The chewing efficiency tended to decrease at insertion of the new denture (T0–T1; *P* = .050), but increased steadily between T1 and T2 (*P* = .032) as well as between T2 and T3 (*P* = .012) (*significant difference). *(b)* The maximum bite force tended to decrease following insertion but significantly increased between T2 and T3 on the right side (right, *P* = .047; left, *P* = .093).

Chewing efficiency with the old denture appeared to be negatively correlated with PRCG brain activity during lip pursing (*r* = –0.624, *P* = .054).

Bite Force

The maximum bite force tended to decrease following insertion of new dentures (*P* > .05), but significantly increased after dentures had been worn for 3 months; this was apparent on the right side (Wilcoxon signed rank test, *P* = .047) (Fig 4b). A Spearman's rho correlation analysis revealed a negative correlation between brain activity in the postcentral and precentral gyrus during jaw tapping and maximum bite force on the right side at the time of immediate issue of the denture (T1) (POCG: *r* = –0.648, *P* = .043; PRCG: *r* = –0.612, *P* = .060).

There was no correlation between the maximum bite force, the S/T scores, or between maximum bite force and age or sex.

Discussion

Previous fMRI studies reported a relationship between oral rehabilitations and specific patterns of brain activation from specific brain regions with jaw clenching[11,12,25] and chewing tasks.[25,40] The primary sensorimotor cortex showed increased activation during clenching in edentulous subjects with implant-supported fixed prostheses, as well as mandibular implant-supported removable overdentures in comparison with complete dentures.[11] The decreased activation during chewing with the overdentures in the same area of the sensorimotor cortex suggests either a role of the task itself or the process of adaptation after treatment. The present study investigated the first prospective cohort and confirmed neuroplastic changes during the adaptation to the new oral situation, and provided evidence that denture replacement is associated with identifiable physiological adaptation.

Due to the technical complexity of the experimental design and the cost involved in this study, only 11 participants were recruited for these pilot recordings. The results show that cortical changes seemed to occur over time where brain activity, in both the precentral and postcentral gyrus, showed a trend towards an increase after 1 week during jaw-clenching and jaw-tapping tasks. After 3 months, the level of activity during each of these two tasks appeared to have returned to that observed with the old dentures. These findings suggest a possible habituation process. Interestingly, this cascade was not observed with lip pursing. A possible explanation is that this task primarily involves facial rather than masticatory muscles and is independent of the dental occlusion; as a result, it may be less influenced by the initial insertion of new dentures. The association between S/T score and brain activity during lip pursing may be related to the broader movement range with denture retention and stability. It is well known that complete dentures should be located within the optimal neutral zone between lips, cheeks, tongue, and denture-bearing area, and that the development of neuromuscular skills is required for effective chewing. The functional benefits of renewing complete dentures are progressive and may be evident sometime after insertion.[9,41] Nevertheless, in the literature depending on the outcome measure and the assessment methods used, there is no defined time span for denture adaptation. Furthermore, adaptation is required with each denture adjustment, such as occlusal equilibration or relining of the denture base, which can explain the restart of the process associated with bone resorption after several months, thus affecting prosthesis fit.

The lack of correlation between maximum bite force and brain activation during jaw clenching suggests that bite force was not correlated with high-level activation in the sensorimotor cortical region. The significant increase in activation in regions of interest at T1 compared with T0 during the jaw clenching was not reflected in the maximum bite force. However, if mucosal soreness had occurred during the first week of wearing new dentures, this may have affected the results. Several studies assessed maximum bite force after renewal or optimization of complete dentures,[10,42] but they failed to show consistent improvement in maximum bite force with new prostheses.

fMRI is based on the detection of a weak signal in the presence of a large noise, thus cautious interpretation is required. Previous clinical studies suggested that variation of brain activity may be based on parameters that were not controlled in the present study. A control group would have helped with the reproducibility of fMRI analysis. Further, it has to be considered that accurate repeating of tasks several times in a MRI scanner is difficult. Individual analysis in other fMRI studies showed large individual differences in activation of the primary sensorimotor cortex with complete dentures.[11,12] Some subjects showed very little fMRI BOLD signals during chewing, for example; although there is evidence that the face sensorimotor cortex contributes to semiautomatic masticatory movements.[17] Another study reported little activation during clenching with complete dentures.[11] Possible explanations for this lack of activation of regional brain activity is that alteration of chewing-induced activity occurs at a subcortical level within the brain stem and does not require activation of the sensorimotor cortex. Such activity may possibly also be masked by denture mobility and the general oral condition. In the same study, subjects with implant-supported overdentures and implant-supported fixed prostheses showed a similar pattern of brain activity to dentate subjects. This suggests that removable complete denture adaptation may play a major role in variability of brain activation rather than patient-related factors.

The stability and retention of complete dentures is a poor predictor of patient satisfaction.[43] Ellis et al[43] reported no consistent relationship between S/T score and brain activation. The process of adaptation to new dentures is complex. Adaptability is defined as the ability to change a certain function to reflect a new context, and it involves psychological as well as physiological adaptation. Psychological adaptation is suggested to depend on personality traits, cognition, motivation, expectation, and socioeconomic and demographic factors. The success of psychological adaptation is a subjective response, dependent on acceptance of incorporation of the denture as part of the body, rather than being perceived as "foreign."

Conclusion

Immediate cerebral cortical changes followed the insertion of replacement dentures. Patient responses were monitored over an observation period of 3 months and progressive changes approached pre-insertion activity levels for motor tasks involving changes in the occlusion. These data confirm that cortical neuroplastic changes occur in association with adaptation to replacement complete dentures.

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