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Impact of Treatment with Unilateral Implant-Supported Fixed Partial Prosthesis on the Frequency of Masticatory Side Switches in Patients with Unilateral Posterior Missing Teeth

Keywords

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ABSTRACT

This study aimed to determine the impact of treatment with an implant-supported fixed partial prosthesis (ISFPP) on the frequency of masticatory side switches in patients with unilateral posterior missing teeth. This was a prospective study of 30 patients with unilateral posterior missing teeth treated with one-, two-, or three-unit ISFPPs. Comparison was with 10 healthy individuals with complete natural dentitions. Each participant performed masticatory assays, which involved chewing pieces of silicon inside a latex bag, at baseline and at 3-months' follow-up. The frequency of masticatory side switches was reported as the masticatory side-switch index: the number of side switches divided by the maximum number of possible switches. Data were analyzed by Kruskal–Wallis, Mann–Whitney U test, or Wilcoxon test, as appropriate. At baseline, the masticatory side-switch index was lower only in patients with three missing teeth than in controls. At 3 months after treatment, a significant increase in the masticatory side-switch index was only observed in patients treated with three restorative units. Treatment with ISFPPs does not change the masticatory side-switch frequency in patients with unilateral posterior missing teeth, though it could increase it in patients with three missing teeth.

INTRODUCTION

Partial edentulism is a relatively frequent problem, with those who lose posterior teeth often having impaired masticatory function.[1,2] It is possible to replace these missing teeth with tooth-supported fixed or removable prostheses or with implant-supported fixed partial prostheses.[3] Prosthodontic treatment seeks to restore or improve masticatory function,[4] including masticatory performance, chewing rate, and masticatory laterality.[5-7]

Although mastication may be bilateral or alternate on each side, it is thought that most people have a dominant side.[8,9] However, a unilateral masticatory pattern, or consistent unilateral chewing, may be associated with restricted mobility,[10] underweight,[11] temporomandibular disorders,[12] possible sleep

bruxism,[13] and lower oral health-related quality of life.[14] Chewing simultaneously or alternately on both sides may have physiological advantages, including enhanced saliva production to facilitate bolus formation, enhanced flavor release and taste appreciation, reduced risk of muscular fatigue, and active food reduction on the contralateral side, increasing efficiency.[15,16]

Another aspect of masticatory laterality is the frequency of side changes during chewing.[17] When healthy people masticate through unilateral cycles, placing the food on one side of the mouth only, most occasionally change or switch the side of mastication that produces an alternately unilateral chewing pattern.[15,18] The number of side switches usually varies between 1 and 3 per chewing sequence of approximately 20 cycles, though it may depend on the type of food, thus substantial intra- and interindividual variation is reported.[15,18-20] Advantages and inconveniences of the frequency of side changes are still unclear in healthy people with normal occlusion, but it might potentiate the advantages of chewing simultaneously or alternately on both sides.[15] Data from an observational study showed that individuals with low side-switch frequencies during mastication had better masticatory performance than those with higher side-switch frequencies.[17] Little is known about whether prosthodontic treatment influences the frequency of masticatory side switches. Given that treatment with an ISFPP can improve several aspects of masticatory function, such as masticatory performance, masticatory rhythm, and the degree of bilateral chewing,[21-23] it would be interesting to know if this treatment could also improve the frequency of masticatory side switches.

The objective of this study was to determine the impact of treatment with an ISFPP on the frequency of masticatory side switches in patients with unilateral posterior missing teeth. We also explored whether the number of restorative units and changes in various masticatory factors due to ISFPP treatment were related to a change in side-switch frequency. The null hypothesis was that ISFPP treatment would not alter masticatory side-switch frequency in patients with unilateral posterior missing teeth.

MATERIALS AND METHODS

Thirty-one patients with unilateral posterior missing teeth who attended the University of Barcelona's Dental Hospital from October 2015 to July 2018 were invited to participate in this prospective study. For inclusion, participants were required to be missing at least one premolar or molar on a single side, with natural tooth antagonists, that was to be restored with an ISFPP. Those with any orofacial pain, periodontal disease, receiving active orthodontic treatment, or requiring restorative treatment within the 3 months after prosthesis placement were excluded. The sample size was calculated based on masticatory performance as the primary outcome.[21] Ten healthy individuals with complete natural dentitions were included in a control group by convenience sampling. All cases and controls had participated in a previous investigation.[21-23]

Informed consent was provided by all participants, and the study was approved by the Ethics Committee of University of Barcelona's Dental Hospital (Code 2015/27). All the procedures were carried out in accordance with the principles of the Helsinki Declaration. The STROBE statement was followed in reporting the study results.[24]

The clinical procedures have been described in detail in previous investigations.[21-23] A single implant was placed in participants who had one missing tooth and two implants were placed in those individuals with 2 or 3 missing teeth. At 90 days after surgery, screw-retained metal-ceramic prostheses were fabricated and each ISFPP was screwed in place and adjusted to each patient's occlusion at the intercuspal position (i.e., contact at heavy clench and no contact at light clench).[25] No contact was allowed during laterotrusion or protrusion.

Age, sex, and number of teeth were obtained by clinical history and examination. Each participant performed one masticatory assay consisting of five trials of 20 chewing cycles of 2 g of Optozeta (Optosil P Plus, Heraeus Kulzer; Zetalabor, Zhermack). Optozeta tablets were 5 mm thick and 20 mm in diameter; they were made according to the instructions of Albert *et al.* and cut into quarters, with three of the quarter tablets placed in a latex bag and sealed.[5,6,26] In the masticatory assay, the participant was instructed to chew the latex bag naturally, without forcing any side to dominate.[27]

Masticatory performance was evaluated by the degree of comminution of the silicon test food. For each participant, particles from all the five trials (10 g) were dried and passed through a series of eight sieves (0.25–5.6 mm) while being shaken for 1 min. After the cumulative weight distribution of the sieve contents was determined, the median particle size (MPS) was calculated for each subject using the Rosin–Rammler equation [$Qw(X) = 1-2E-(X/X_{50})^b$], where Qw (X) is the fraction of particles by weight with a diameter smaller than X, the MPS (or X_{50}) is the size of a theoretical sieve through which 50% of the weight can pass, and b describes the breadth of particle size distribution.[28,29]

During each of the five trials, an operator observed the side toward which the jaw moved while closing for each masticatory cycle. Therefore, each cycle was classified as right, left or no side. A video camera (Sony HDR-UX7E) recorded mandible displacement while closing during each mastication trial. Mandible lateralization while closing was counted for each chewing cycle using a slow-speed playback mode to confirm the operator's visual record.[5] The asymmetry index (AI) was calculated by considering all cycles as follows: (number of right strokes − number of left strokes) / (number of right strokes + number of left strokes).[30-32] The unilateral chewing index was the absolute AI value, expressing the degree of unilateral mastication regardless the side.[7]

The time spent to complete 20 masticatory cycles per trial was recorded, and the frequency of the average masticatory cycle per trial was calculated. Masticatory frequency was defined as a ratio of the masticatory cycle number to the masticatory time, expressed as cycles per minute.[33]

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The number of masticatory side switches was counted using a slow-speed playback mode of the recordings. A masticatory switch from right to left or from left to right was scored 1 point. A masticatory switch from right or left to center or from center to left or right was scored 0.5 point. It was considered a centered masticatory cycle when the jaw closed vertically toward the intercuspal position. To obtain the masticatory side-switch index, the total number of points was divided by the maximum number of possible switches (19 times in this study).

Masticatory performance, laterality, and frequency, as well as the frequency of masticatory side switches, were determined before and 3 months after prosthetic treatment in the ISFPP group and at baseline and 3 months in the control group.

The masticatory side-switch data were not distributed normally according to the Shapiro–Wilk test. Therefore, the control and treated groups were compared by Kruskal–Wallis tests, and intra-individual differences between the data at baseline and at 3-months were analyzed by Wilcoxon tests. Correlation between change in the masticatory side-switch index and change in masticatory performance and frequency, unilateral chewing index, and number of restorative units was assessed by the Spearman rho test. We considered p values of < 0.05 to be statistically significant. All analyses were conducted using IBM SPSS Version 27.0.

RESULTS

One participant treated with a single implant-supported prosthesis was excluded because she was not available for the second follow-up visit. This resulted in 30 participants (17 women and 13 men) in the ISFPP group and 10 participants (8 women and 2 men) in the control group being included for analysis. Their masticatory characteristics at baseline are shown in Table 1. There were no significant differences between the control and ISFPP groups regarding masticatory performance, symmetry, or rhythm ($p > 0.050$). Fifteen, 9, and 6 participants received 1, 2, and 3 restorative units, respectively.

Masticatory side-switch data for participants are shown in Table 2. At baseline, the masticatory side-switch index was lower in patients with 3 missing teeth than in those with 1 missing tooth or in controls ($p = 0.042$). At 3 months after treatment, no significant differences were observed in the masticatory side-switch index between groups ($p = 0.852$). A significant increase in the masticatory side-switch index was observed 3 months after treatment in patients who received three restorative units ($p = 0.042$) *(Figure 1)*.

In the ISFPP group, a significant correlation between change in the frequency of masticatory side switches and change in the degree of masticatory unilaterality (Spearman rho = -0.53; $p = 0.003$) was observed *(Figure 2)*. No significant correlation was found between change in the masticatory side-switch frequency and change in either masticatory performance (Spearman rho = -0.12; $p = 0.523$) *(Figure 3)* or masticatory rhythm (Spearman rho = -0.11; $p = 0.563$). Similarly, no significant correlation was found between change in the masticatory side-switch frequency and the number of restorative units (Spearman rho = 0.271; $p = 0.091$).

DISCUSSION

This study suggests that patients missing one or two unilateral posterior teeth does not have a different masticatory side-switch frequency to those with natural dentitions. However, patients missing three teeth have a fewer chewing side switches than dentate controls and increased the frequency of chewing side switches by 3 months after treatment with ISFPPs, achieving similar values to those with natural dentitions. As expected, this increased frequency of chewing side switches after ISFPP treatment was associated with a decrease in unilateral chewing. These results indicate that restoring unilateral posterior missing teeth may increase the ability of participants to masticate with either side, thereby increasing the symmetry of mastication. Changing sides more often may be beneficial.

Table 1. Participants characteristics at baseline by treatment group.

Group	n	Age (years)	Median Particle Size (mm)	Unilateral Masticatory index	Masticatory frequency (Cycles/min)
No-treatment	10	35.6 (12.6)	3.68 (1.2)	0.37 (0.4)	73.8 (10)
ISFPP Group	30	58.8 (13.5)	4.03 (1.3)	0.66 (0.4)	69.1 (11)
1 restorative unit	15	57.6 (17.1)	3.93 (1.2)	0.57 (0.4)	68.6 (11)
2 restorative units	9	60.7 (8.7)	3.69 (1.3)	0.79 (0.3)	68.9 (10)
3 restorative units	6	58.8 (10.6)	4.80 (1.1)	0.70 (0.4)	70.6 (14)
Significance Kruskal-Wallis		0.004	0.276	0.073	0.687

Results are shown as mean (SD). Abbreviations: ISFPP: implant-supported fixed partial prosthesis; SD: standard deviation.

Table 2. Masticatory Side-Switch Index by treatment group at baseline and follow-up

Group	n	Masticatory side-switch index Mean (SD)		Changes in the masticatory side-switch index at 3 months. Mean (95%CI)	Significance*
		Baseline	Follow-up at 3 mo.		
No-treatment	10	0.061 (0.05)	0.059 (0.05)	-0.002 (-0.01 to 0.01)	0.755
ISFPP Group	30	0.053 (0.07)	0.067 (0.07)	0.014 (-0.01 to 0.04)	0.330
1 restorative unit	15	0.070 (0.07)	0.066 (0.06)	-0.004 (-0.03 to 0.02)	0.610
2 restorative units	9	0.059 (0.09)	0.081 (0.08)	0.022 (-0.05 to 0.09)	0.396
3 restorative units	6	0 (0)	0.046 (0.06)	0.046 (-0.03 to 0.12)	0.042
Significance Kruskal–Wallis		0.042	0.852		

*Wilcoxon test between baseline and 3 months' follow-up. Follow-up was at 3 months after treatment.
Results are shown as mean (SD). Abbreviations: CI: confidence interval; ISFPP: implant-supported fixed partial prosthesis; SD: standard deviation

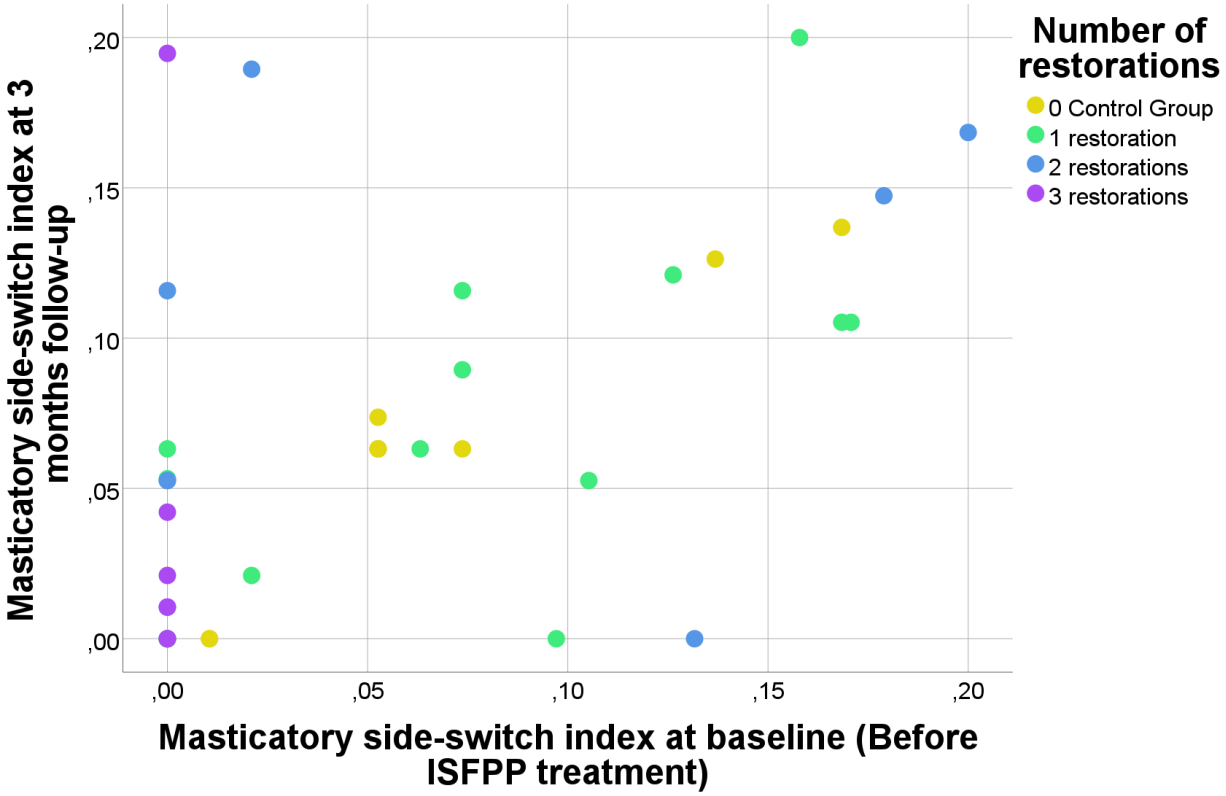

Figure 1: Scatterplot of the masticatory side-switch index by treatment group at baseline and at 3 months.

The increased frequency of chewing side switches was not associated with improved masticatory performance after treatment with ISFPP. An observational study revealed that individuals with a low side-switch frequency during mastication exhibited better masticatory performance than those with a high side-switch frequency.[17] If a cause-effect relationship really exists between low side-switch frequency and high masticatory performance, we expected that an increase in side-switch frequency after ISFPP treatment would be associated with less improvement in masticatory performance, but this was not observed. This could be due to the fact that many factors are involved in improving masticatory performance after ISFPP treatment, making the impact of side-switch frequency on masticatory performance insufficiently high to have been detected in this observational study. Each change of chewing side is normally accompanied by chewing rhythm distortion,[18]

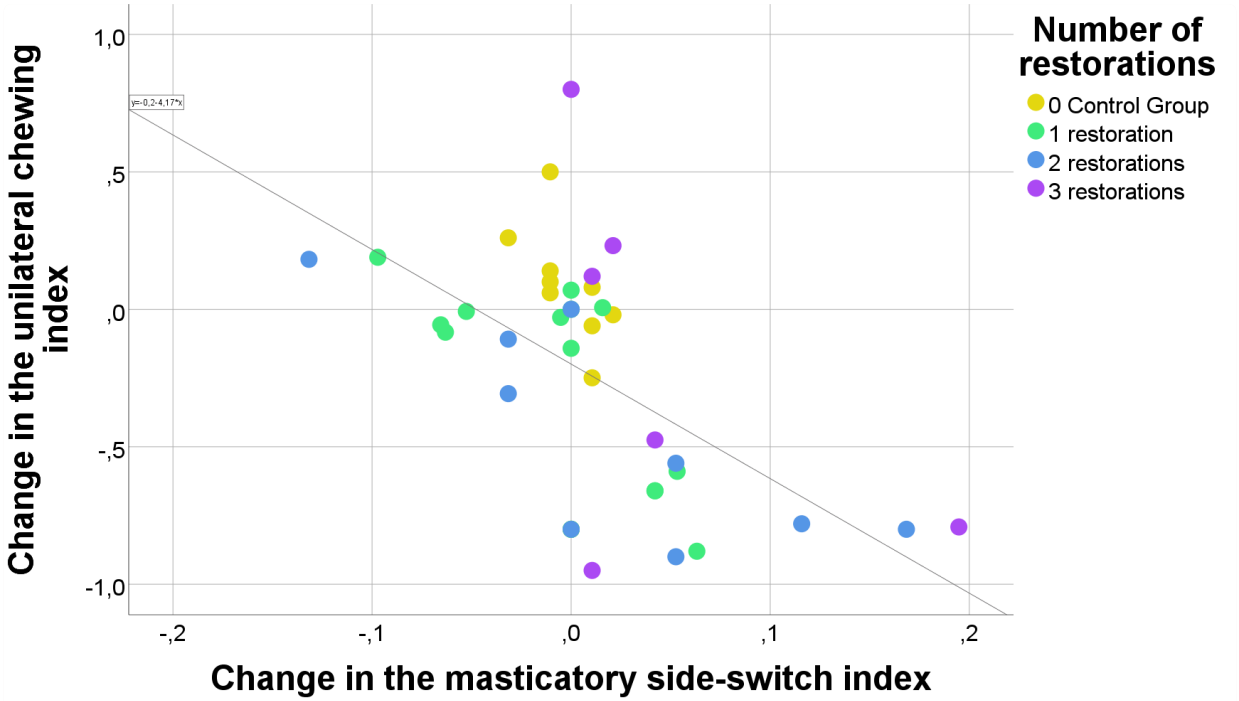

Figure 2: Scatterplot of the change in the degree of masticatory unilaterality at 3 months and the change in the masticatory side-switch frequency at 3 months by treatment group.

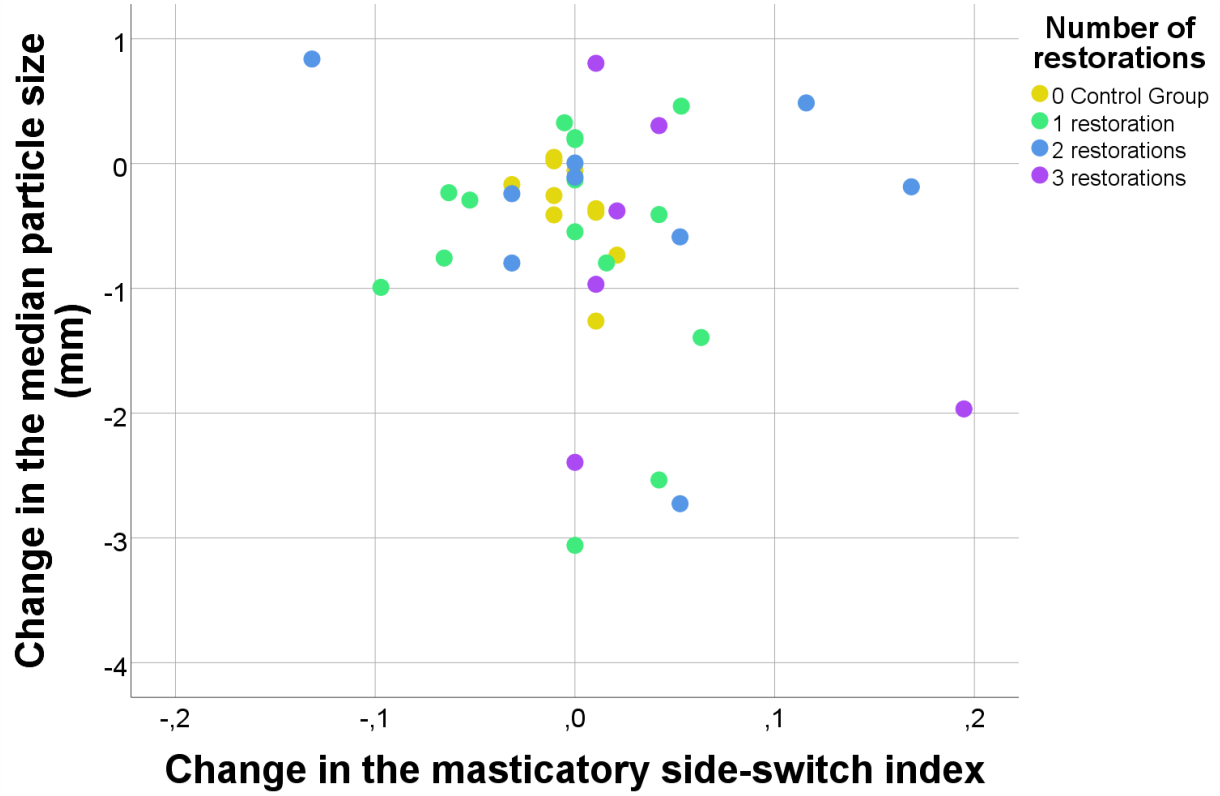

Figure 3: Scatterplot of the change in the masticatory performance at 3 months and change in the masticatory side-switch frequency at 3 months by treatment group

but the low frequency of side switches (0–3 in 20 cycles) meant that the global rhythm was not heavily altered in the present study. A well-controlled experimental study is needed to demonstrate the relationship between side-switch frequency and both masticatory performance and rhythm and to assess the magnitude of these relationships.

In healthy individuals with natural dentitions, the mean frequency of side switches is reported to range from 8% to 30% when eating and swallowing natural foods.[15,17-20] Although the values ranged from 5% to 8% among the control and ISFPP treated groups in the present study, these are consistent with the existing studies,[15,17-20] given that we did not consider the

segregation or aggregation shifts because a non-committable bolus was used as the test food, the participant did not have to swallow it, and masticating hard foods requires more unilateral cycles. The results of the present study in the control group showed high reproducibility at baseline and 3 months (*Figure 1*) in contrast to the relative reproducibility observed while eating bread or biscuits.[19] It is well known that an artificial test food leads to a more uniform masticatory pattern.[28] However, the present results are consistent with the large interindividual variation in side-switch frequency observed while eating chocolate.[20]

When an individual has three missing teeth unilaterally, both the performance and pattern of masticatory function are impaired. The chewing pattern typically slows and suffers less stability of rhythm,[23] more asymmetry,[22] and less side switching. Treatment with ISFPP seems to restore not only masticatory performance but also the normal masticatory pattern of side switching. These patients may choose the number of side switches and when to do it, without any limitation compared with their pre-treatment state. Consequently, treatment with ISFPP in these patients is likely to provide them with more flavor, more saliva secretion, and less fatigue when eating natural foods.[15] Future research should demonstrate these potential benefits of ISFPP by mixed-methods approach, using natural food, to focus on patient perception.

The present results offer support for dental clinicians when making decisions and counseling patients who have unilateral posterior missing teeth and tooth replacement is considered.[34,35] Patients with one or two missing teeth, no reduction in the masticatory side-switch frequency is expected and consequently no prosthodontic treatment might be advised in order to improve this aspect of the masticatory function. However, in patients who have three unilateral posterior missing teeth, an increase in side switching with three ISFPPs can be obtained, achieving functional levels similar to those of individuals with complete natural dentitions. This possible improvement requires discussion along with other potential benefits (e.g., improved masticatory performance, rhythm, and asymmetry, improved aesthetics, and occlusal stability) and costs (e.g., financial, risks, and complications).

The present study has several limitations. Given that an artificial test food was used, we assessed only the comminution phase of mastication and did not consider the mandibular movements during bolus transport just before swallowing. Nevertheless, this is not expected to have affected the results dramatically because more cycles are spent during the comminution phase. Another limitation is that only one test food was used, even though it is known that the hardness and size of the test food affects masticatory laterality.[30,36] We also expect that these food properties might affect the side-switch frequency, but equally, we do not anticipate that the effect of ISFPP treatment on this outcome depends excessively on the properties of food. The test food was a latex bag with silicone particles that forces the participant to chew in a unilateral or unilateral alternate manner. Although this excludes simultaneous bilateral chewing, this type of test food has been demonstrated to be reliable and valid.[5,6,31]

CONCLUSIONS

Treatment with ISFPPs does not change the masticatory side-switch frequency in patients with unilateral posterior missing teeth. However, in patients with three missing teeth, masticatory side-switch frequency may be improved by 3 months after treatment with an ISFPP, achieving similar levels to those people with a complete natural dentition. This increased frequency of switches after ISFPP treatment is associated with a decrease in the unilateral chewing pattern.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

MANUFACTURERS' DETAILS

- Optosil P Plus, Heraeus Kulzer, Hanau, Germany
- Zetalabor, Zhermack SPA, Rovigo, Italy
- Sony HDR-UX7E, SONY, Tokyo, Japan
- IBM SPSS v27, IBM Corp., Armonk, NY, USA

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