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Original Article

Comparison of Masticatory Performance and Efficiency Between Bilateral and Unilateral Chewing in Adults

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ABSTRACT

Objectives: This study compared masticatory performance (MP) and masticatory efficiency (ME) between bilateral and habitual unilateral chewers and evaluated changes following bilateral chewing guidance. **Methods:** Fifty participants (25 bilateral, 25 unilateral chewers) chewed peanut samples before and after bilateral chewing training. MP and ME were assessed and analyzed using independent and paired t-tests. **Results:** Bilateral chewers showed significantly higher MP (86.80 vs. 80.32, p = 0.011) and ME (187.84 vs. 131.44, p = 0.019) than unilateral chewers. In unilateral chewers, the dominant side improved in MP (80.32 → 85.32, p = 0.008) and ME (131.44 → 163.76, p = 0.034) post-training; the non-dominant side also improved but remained lower than the dominant side. **Conclusions:** Bilateral chewing is more effective than unilateral chewing in masticatory function. Short-term bilateral chewing training enhances MP and ME, particularly in habitual unilateral chewers.

Keywords: Bilateral chewing, Habitual unilateral chewing, Masticatory efficiency, Masticatory performance

1. Introduction

Among the various interrelated components of oral health, mastication refers to the process of breaking down food into smaller particles within the oral cavity, thereby increasing the surface area available for contact with digestive enzymes and promoting thorough mixing with saliva to facilitate absorption in the gastrointestinal tract. Mastication not only aids in mechanical food breakdown for digestion but also exerts wide-ranging effects on systemic health [1].

Masticatory stimulation plays a central role in cognitive function, and the mechanical breakdown of food contributes to the high metabolic rate in mammals by improving the efficiency of energy extraction from food [2]. Although the precise mechanisms by which mastication stimulates brain activity remain unclear, evidence suggests that in older adults, reduced chewing is associated with declines in short-term memory and elevated blood stress hormone levels [3]. Furthermore, muscle activity and length significantly influence bone growth, with masticatory movements playing an important role in the balanced development of facial bones [4-6].

During mastication, the lips, cheeks, and palate assist mandibular and tongue movements while helping regulate intraoral pressure. Several methods are available to evaluate masticatory performance (MP), with one of the most representative being the direct measurement of food

particle comminution using test foods such as peanuts [7]. Current approaches to measuring masticatory efficiency (ME) include assessing the digestive state of chewed food, counting functional teeth, measuring occlusal contact area, determining the degree of food comminution, and evaluating the chemical changes in food resulting from mastication [7-10]. Given that the primary function of mastication is the mechanical breakdown of food, particle-size analysis provides one of the most accurate measures of ME.

Previous studies have reported that habitual unilateral chewers—those who predominantly chew on one side regardless of food type—are more likely to exhibit worsening periodontal status, with an increased community periodontal index (CPI) score correlating with a greater tendency toward unilateral chewing. We hypothesize that individuals with habitual unilateral mastication, irrespective of side preference, exhibit fewer functional masticatory units and reduced chewing efficiency compared to those with bilateral mastication, and that appropriate masticatory exercise may improve these outcomes [11,12].

Therefore, the purpose of this study was to compare MP and ME between bilateral and habitual unilateral chewers using a food comminution test, and to investigate changes in these parameters among habitual unilateral chewers after a period of bilateral chewing guidance.

2. Materials and Methods

2.1. Design and setting

This non-equivalent quasi-experimental study measured differences in MP and ME between bilateral and unilateral chewers and examined changes in these parameters before and after a period of bilateral chewing guidance, education, and training. The study was conducted in accordance with the Declaration of Helsinki, with ethical approval obtained from the Institutional Review Board of D University (IRB No. DKU 2016-10-014). The trial was also registered with the Clinical Research Information Service (CRIS No. KCT00005962).

2.2. Participants

Fifty adult residents of Cheongju, Chungcheongbuk-do, South Korea, were recruited for this study. The required sample size was calculated for a two-group mean comparison with an effect size of 0.85 and a statistical power of 0.90, resulting in a total of 50 participants. Of these, 25 were habitual bilateral chewers and 25 were habitual unilateral chewers, defined as those who predominantly chewed on one side regardless of direction. Inclusion criteria were: (1) no missing teeth in the oral cavity, (2) absence

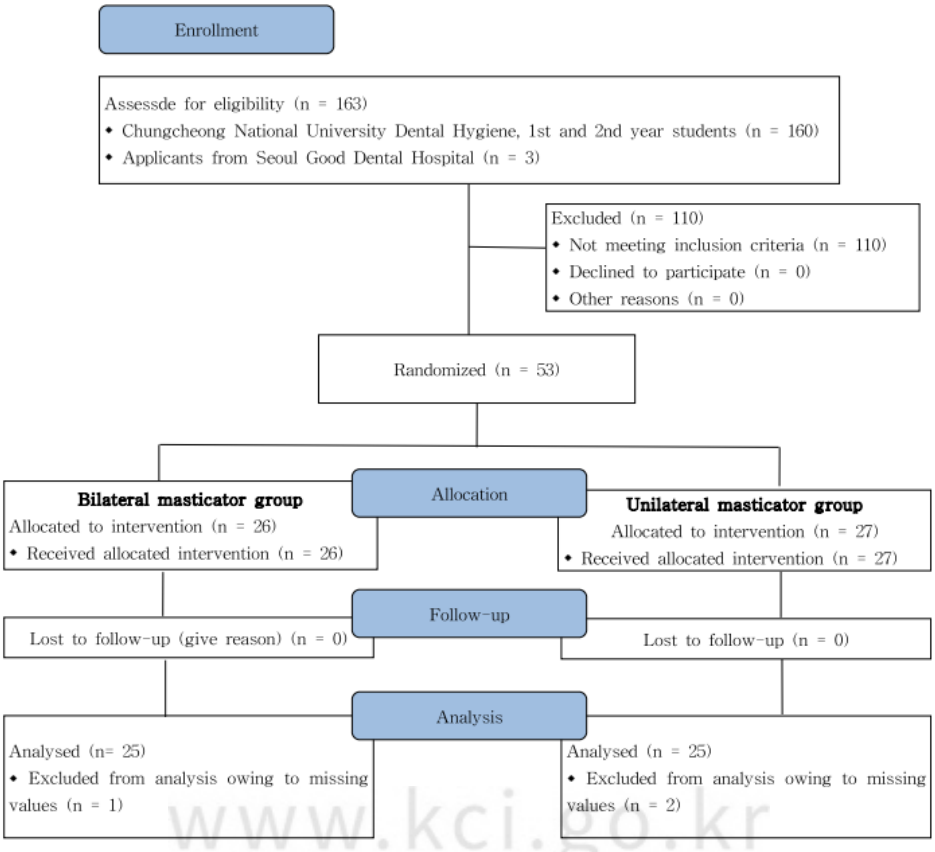

Fig. 1. Flowchart of participants

of orthodontic appliances, (3) no occlusion involving the third molars, and (4) age between 20 and 39 years, with voluntary consent to participate in the clinica trial. The participant selection process is shown in Figure 1.

2.3. Intervention

MP and ME were calculated using the food comminution test, in which the degree of particle breakdown after chewing is used to evaluate ME [1,8,10,13]. Peanuts were selected as the test food because they are of appropriate size, have uniform hardness, and can be easily recovered after mastication.

Participants in the bilateral chewing control group performed the test once. Participants in the habitual unilateral chewing experimental group performed the test twice—once before and once after the bilateral chewing intervention. For the habitual unilateral chewers, both the dominant and non-dominant chewing sides were tested using the same procedure, regardless of left or right side preference.

The bilateral chewing intervention for habitual unilateral chewers was as follows: beginning the day after the first test, participants were instructed to chew 1 g xylitol gum (21 pieces provided) on the non-dominant side for 30 minutes, three times per day (morning, noon, and evening). In addition, they were asked to consciously practice bilateral chewing during all meals and snacks for two weeks. Exactly two weeks after the first test, the food comminution test was repeated on both the dominant and non-dominant sides using the same procedure as before.

2.3.1. Measurement of Masticatory Performance (MP)

For the measurement of MP, 3 g of roasted peanuts were divided into five portions, each chewed 20 times. The chewed sample was then expectorated into a beaker containing 5 mL of 0.3% neutral detergent solution, passed through a 10-mesh sieve, and filtered using filter paper. The filtrate was dried at 100 °C for approximately 1 hour, and the weight was measured to the nearest 0.1 g. The percentage of the dry weight of the material that passed through the sieve relative to the standard dry weight was calculated using the following formula:

MP = (Dry weight of the sample passed through the sieve / Standard dry weight) × 100

2.3.2. Calculation of Masticatory Efficiency (ME)

ME was measured based on the criterion defined by Manly et al., in which a normal value is established when 78% of the total amount of a peanut sample chewed 20 times passes through a 10-mesh sieve [1,8,10,13].

ME = (20 / Number of chewing strokes required by the subject to achieve 78% masticatory performance) × 100

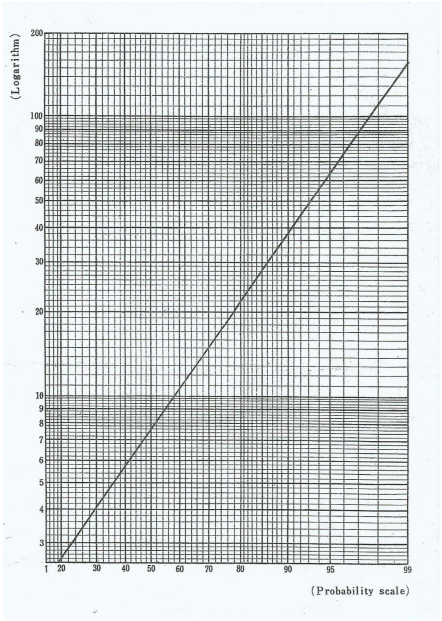

Fig. 2. Logarithm graph. Relationship between masticatory performance (MP) and the number of chewing strokes. MP is plotted on the x-axis (probability scale) against chewing strokes on the y-axis (log scale). Line a shows the reference for healthy individuals. In this example, ME is 43% (20/46 × 100).

2.4. Statistical analysis

Descriptive statistics were calculated using SPSS software (IBM SPSS Statistics 28.0 for Windows; SPSS Inc., Chicago, IL, USA). Differences in MP and ME between bilateral and unilateral chewers were analyzed using paired t-test and independent t-test.

3. Results

3.1. MP and ME of bilateral and habitual unilateral chewers

MP was significantly higher in bilateral chewers (86.80 ± 6.87) than in habitual unilateral chewers (80.32 ± 10.04) ($p = 0.011$). ME was also greater in bilateral chewers (187.84 ± 102.33) compared with habitual unilateral chewers (131.44 ± 50.99) ($p = 0.019$). (See Fig. 3).

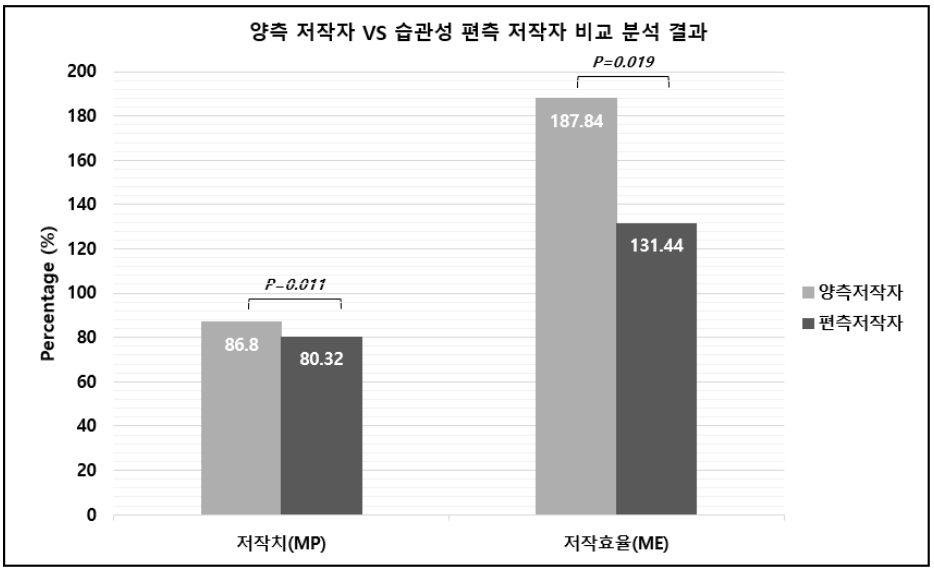

Fig. 3. Difference in masticatory performance and masticatory efficiency of bilateral and habitual unilateral *by independent t-test at α=0.05: M ± SD = Mean ±Standard deviation

3.2. Comparison of MP and ME between the dominant and non-dominant chewing sides in habitual unilateral chewers

In the comparative analysis of MP and ME between the dominant and non-dominant chewing sides in habitual unilateral chewers, the dominant side showed a higher MP (80.32 ± 10.04) than the non-dominant side (76.40 ± 8.19) (p = 0.019). ME was also greater on the dominant side (131.44 ± 50.99) compared with the non-dominant side (102.52 ± 41.66) (p = 0.001). (See Fig. 4).

3.3. Comparison of MP and ME between the main chewing side (MC) and the non-chewing side (NC) before and after bilateral chewing guidance in habitual unilateral chewers

In the pre-post comparison of the dominant chewing side in habitual unilateral chewers, MP increased from 80.32 ± 10.04 before the intervention to 85.32 ± 6.82 after the intervention (p = 0.008), and ME increased from 131.44 ± 50.99 to 163.76 ± 79.85 (p = 0.034). For the non-dominant chewing side, MP improved from 76.40 ± 8.19 pre-intervention to 82.72 ± 6.66 post-intervention (p = 0.001), and ME increased from 102.52 ± 41.66 to 133.36 ± 41.86 (p = 0.001). (See Fig. 5).

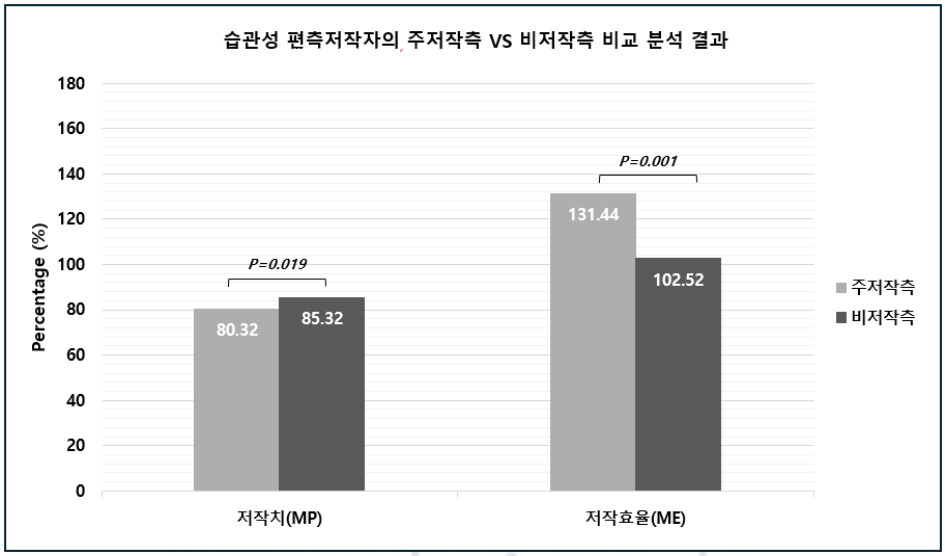

Fig. 4. Difference in masticatory performance (MP) and masticatory efficiency (ME) between main chewing and non-chewing of habitual unilateral. *by paired t-test at α=0.05: Unit: M ± SD = Mean±Standard deviation

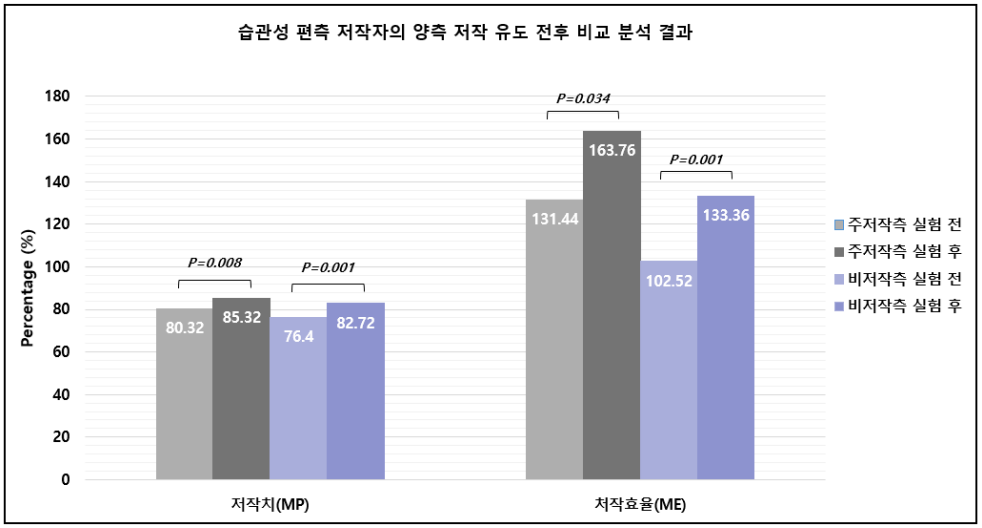

Fig. 5. A comparative analysis of the main chewing & non-chewing side before attracting the bilateral chewing in habitual unilateral masticators versus the main chewing & non-chewing side after driving the bilateral chewing *by paired t-test at α=0.05: Unit: M ± SD = Mean±Standard deviation

4. Discussion

This study demonstrated that bilateral chewers exhibited higher MP and ME than habitual unilateral chewers [14.15]. Furthermore, in habitual unilateral chewers, the dominant chewing side showed significantly greater MP and ME compared to the non-dominant side [16]. After two weeks of bilateral chewing guidance and training, both the dominant and non-dominant sides in habitual unilateral chewers showed significant improvements in MP and ME, indicating that even a relatively short intervention can yield measurable functional benefits in young adults with otherwise healthy oral conditions.

The findings are consistent with previous studies reporting that approximately 45% of individuals maintain a consistent dominant chewing side, although this preference is unrelated to handedness, footedness, or sensory dominance [1,14-18]. Unilateral chewing has been associated with various adverse effects, including increased risk of dental caries, periodontal deterioration, occlusal force imbalance, and craniofacial skeletal asymmetry [19]. In contrast, bilateral chewing promotes balanced occlusal contact, symmetrical masticatory muscle activity, and may help maintain optimal oral function [4-6,20-22].

Prior investigations have shown that unilateral chewers typically exhibit greater occlusal force on the dominant side compared with the non-dominant side, particularly among females, whereas bilateral chewers present relatively symmetrical occlusal force [23,24]. Our results align with these observations, as the experimental group demonstrated greater MP and ME on the dominant side before intervention and notable bilateral improvement after intervention. The positive effect observed within just two weeks supports earlier findings that targeted masticatory muscle training—such as chewing gum exercises—can induce measurable changes in occlusal relationships and craniofacial morphology [25].

The functional role of mastication extends beyond food comminution to include stimulation of salivary flow, facilitation of digestion, maintenance of oral cleanliness, promotion of blood circulation in oral tissues, and activation of brain function [20-22]. Abnormal or reduced mastication may lead to disuse atrophy of the masticatory system. Our results suggest that bilateral chewing guidance could serve as a practical and effective intervention for improving masticatory function, particularly in younger adults with habitual unilateral chewing patterns.

Future studies should explore the long-term effects of bilateral chewing training, its impact on older populations or individuals with compromised oral health, and potential associations with systemic health outcomes such as metabolic syndrome prevention.

This study has several limitations. First, the sample size was relatively small and limited to adults aged 20–39 years residing in a single urban area, which may limit the generalizability of the findings to other age groups or populations with different oral health conditions. Second, the intervention period of two weeks, although sufficient to demonstrate short-term functional improvement, does not provide insight into the long-term sustainability of these changes. Third, the classification of chewing patterns relied partly on self-reported questionnaires and interviews, which may introduce recall bias despite the repeated validation process. Finally, dietary habits and individual variations in mastica-

tory muscle strength were not controlled, which could have influenced the outcomes.

Despite these limitations, the study has notable strengths. It used an objective, reproducible measurement method—the food comminution test—to assess both MP and ME. The study also implemented a standardized bilateral chewing intervention and measured outcomes for both the dominant and non-dominant sides, providing a comprehensive evaluation of functional change. Moreover, the inclusion of a healthy young adult cohort minimized confounding effects related to missing teeth, prosthetic appliances, or advanced periodontal disease, thereby allowing a clearer assessment of the intervention's efficacy. Furthermore, future research is suggested to include a more diverse range of participants, such as older adults, patients with periodontal disease, and prosthodontic patients, with the aim of developing patient education programs to alleviate masticatory discomfort.

5. Conclusions

In adults, bilateral chewers demonstrated greater MP and ME than habitual unilateral chewers, and the dominant chewing side in habitual unilateral chewers was more efficient in both measures than the non-dominant side. Therefore, education and training aimed at promoting bilateral chewing over a defined period may serve as an effective approach to improving MP and ME.

Author Contribution

Conceptualization: GS Chun and MY Yun; Data collection: MY Yun; Formal analysis: MY Yun and JH Jang; Writing-original draft: MY Yun and JH Jang; Writing-review & editing: MY Yun and JH Jang

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Conflicts of Interest

The authors declare no conflict of interest.

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