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Effect of chewing speed on the detection of a foreign object in food

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SUMMARY Accidentally biting hard on a piece of hard foreign object in food is among the causes of tooth fracturing and could be associated with oral sensibility. This study has investigated the effect of chewing speed on the ability to detect a foreign object in food in human. Fourteen healthy subjects were asked to randomly chew one of 10 cooked rice balls, five of which containing a foreign object made from a tiny uncooked rice grain, until they detected the rice grain. Each subject chewed the test foods both at 50 (slow) and 100 (fast) chews min^{-1}. The accuracy of detection and the number of chews before detection (CBD) were recorded and compared between the two chewing speeds using paired *t*-tests. The results showed that almost all subjects detected the foreign object by biting. The accuracy of detection was more than 90% and not significantly different between slow and fast chewing but the mean CBD in slow chewing (11·7 ± 1·3 chews) was significantly different from that in fast chewing (20·7 ± 1·9 chews; $P < 0{\cdot}001$). The study showed that slow chewers required less number of chews before a foreign object in food could be detected and was, presumably, more effective in detecting the object compared to fast chewers. If each chew bears equal probability of teeth encountering the foreign object, slow chewing might also reduce the chance of accidentally biting hard on the foreign object and fracturing the tooth.

KEYWORDS: **eating, mastication, sensation, tooth fractures, food intake, swallowing**

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Introduction

Human subjects chew food with different speeds, ranging from 76 to 108 chews min^{-1} (1, 2), yet the speed seems to be consistent throughout the whole meal (2). The central pattern generator (CPG) could account for the variation of the chewing speed, but other factors could also modulate the chewing speed such as hurriedness, hunger and food palatability (1). Chewing speed has been shown to affect masticatory performance, fast chewing resulting in a larger median particle size of chewed food (3). Fast gum chewing is also associated with less energy expenditure per chew compared to slow gum chewing (4). Fast eating has been shown to be associated with overweight in schoolchildren (5) and adults (6), although it is not clear whether this is due to the increased chewing speed or decreased number of chews.

Unexpectedly chewing on foreign objects, such as tiny bones or stones, during a meal could result in an irreversible damage to teeth. Periodontal, muscle and auditory receptors are thought to be involved in sensing food hardness and might help detect any foreign object bit on the occlusal surfaces (7). Intradental mechanoreceptors might also contribute to the detection of a hard object as biting on a hard object imposes a high stress on the tooth crown and subsequently results in larger dentinal fluid flow (8). The ability to detect the thickness of an object placed between upper and lower teeth has long been studied, and the detection threshold has been shown to be increased in patients with dentures (9), inlays

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(10) and implants (11). The threshold is also increased during chewing (12, 13). The ability to detect a foreign object in food might be reduced during fast chewing as it is associated with a shorter occlusal phase (14, 15). Such a brief tooth–food contact might result in an inadequate stimulation that does not reach the sensory threshold and hence reduces the detection ability.

This study aimed to investigate the effect of chewing speed on the ability to detect a foreign object. This might have an implication on the prevention of tooth fracture caused by accidentally biting on a hard foreign object in food.

Materials and methods

Subjects

The study protocol was reviewed and approved by the Ethical Committee at Khon Kaen University and was undertaken with the understanding and written consent of each subject, according to the Declaration of Helsinki. Fourteen healthy university students (seven females, seven males), without pain and discomfort of the masticatory system, aged 18–24, participated in the study.

Study protocol

The test food was made from steamed rice moulded in a spherical shape, approximately 2 cm in diameter. A piece of uncooked rice grain, sized approximately $2 \times 2 \times 2$ mm, was inserted into the centre of the rice ball to represent a hard foreign object in food as it was adequately hard but edible and did not cause damage to the teeth. Each subject was asked to chew 10 rice balls in a random order with a 1-min break between each rice ball. Five of the 10 rice balls contained the uncooked rice grain whereas another five did not. Subjects were asked to chew the test food until the rice grain was detected, the moment at which the subject rang a bell. If the rice grain was not found, the subject was allowed to chew until the food was swallowed. Each subject followed the above protocol both at slow (50 chews min^{-1}) and fast chewing speeds (100 chews min^{-1}). The chewing speeds were controlled by allowing subjects to listen to the metronome during each test food. The loudness of the metronome was set at the lowest level audible to minimize distraction. The number of chews before the detection of the rice grain (chews before detection, CBD) was counted manually by an observer who sat beside the subject.

Data analysis

The accuracy of either detecting or not detecting the rice grain in 10 rice balls (in percentage) and CBDs was compared between the two chewing speeds using paired *t*-tests. The number of chews before swallowing was also compared for the trials in which subjects did not detect the rice grain. The mode of detection in each trial was recorded if the rice grain was detected by teeth or else.

Results

All subjects appeared to be able to follow the metronome correctly and could perform the test with the preset chewing speeds. In most trials, subjects reported that they were able to detect the rice grain in the test food by biting with their teeth. When only trials with correct detection of the rice grain were analysed, the numbers of trials detected by teeth were 63 of 65 trials during slow chewing and 60 of 61 trials during fast chewing.

The mean (±s.d.) accuracy of detection (both with and without rice grain) was $95{\cdot}7 \pm 10\%$ during slow chewing and was $92{\cdot}1 \pm 20\%$ during fast chewing, of which the difference did not reach the statistical difference ($P > 0{\cdot}05$) (Fig. 1a). The mean CBD during slow chewing was $11{\cdot}7 \pm 1{\cdot}3$ chews and was significantly different ($P < 0{\cdot}001$) from that during fast chewing $20{\cdot}7 \pm 1{\cdot}9$ chews (Fig. 1b).

When only the trials without a rice grain were analysed, it was found that the mean number of chews before swallowing during slow chewing was $40{\cdot}6 \pm 4{\cdot}3$ and was significantly different from that during fast chewing ($60{\cdot}2 \pm 5{\cdot}7$ chews; $P < 0{\cdot}001$) (Fig. 2).

Discussion

The accuracy in detecting a foreign object in food did not seem to differ between slow and fast chewing, but in fast chewing, more chews were required before the foreign object was detected. In most trials, subjects were able to detect the foreign object by their teeth. The detection was presumably originated from periodontal mechanoreceptors, intradental receptors, auditory receptors and muscle spindles which

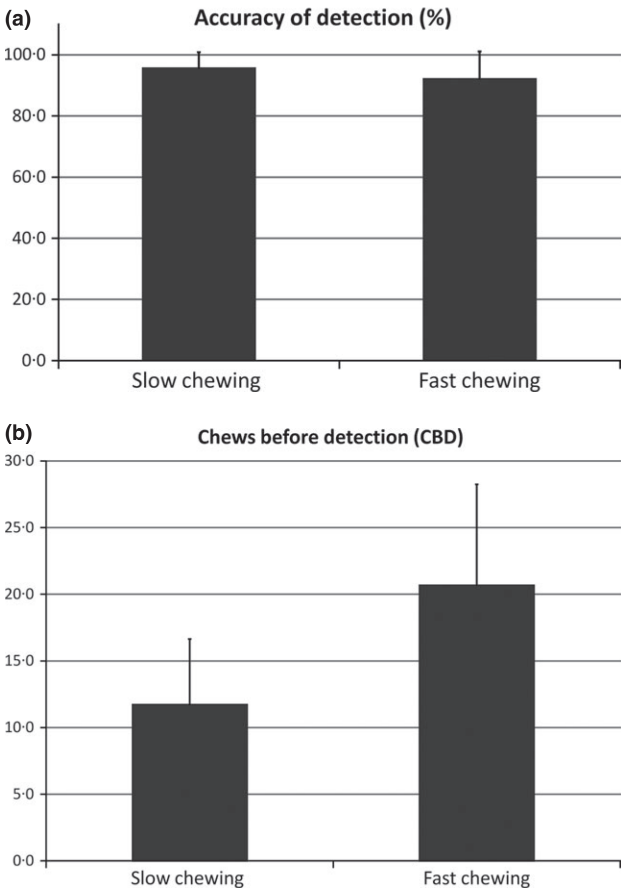

Fig. 1. Mean accuracy in detecting a foreign object (tiny uncooked rice grain) inside cooked rice balls (a), and the number of chews required to detect the object (chews before detection, CBD) (b), during slow and fast chewing (Error bars represent standard deviations).

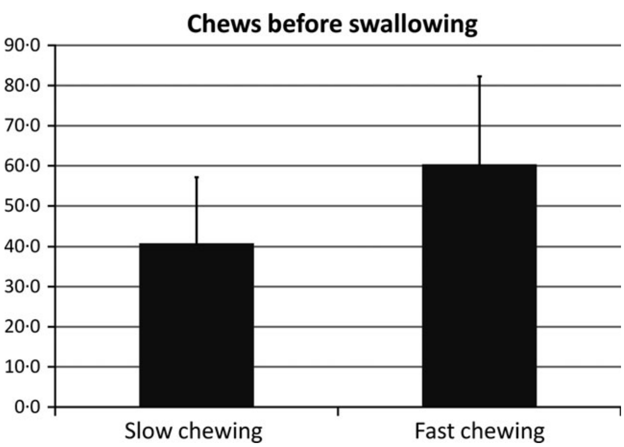

Fig. 2. Mean number of chews before swallowing analysed from trials in which foreign objects were not detected, during slow and fast chewing (Error bars represent standard deviations).

might respond to the tooth–food occlusal contact when the hard foreign object was encountered. Apparently, if there was no restriction in the number of chews, these sensory mechanisms seemed to be effective and accurate so the foreign object could be detected most of the times. In much fewer trials did subjects inform that they could feel the object with their tongue. It was speculated that teeth might be suitable in distinguishing objects with different hardness (i.e. soft steamed rice versus hard rice grain used in this study) whereas the tongue might be better in distinguishing objects with different shapes or surface textures.

On the other hand, the number of CBD was dependent of the chewing speed, being almost twice greater during fast than slow chewing speed (11·7 and 20·7 chews respectively). Three explanations were proposed. Firstly, the detection of a foreign object in food was presumably governed by the chance in which the object was contacted by the occlusal surfaces. Thus, fast chewing had a reduced probability of the tooth–food contact. Secondly, mixing of food bolus might not be thorough enough during fast chewing so there was less chance for the foreign object to be brought onto the occlusal surfaces. Thirdly, with increased chewing speed, the detection threshold might be more difficult to be reached. To support the latter, it has been shown that the peripherally mediated sensory inputs were less effective in modulating the activity of jaw closing muscles during fast chewing (16), presumably due to the too short sensory processing time.

Taken together, the present study suggested that although the detection accuracy of a foreign object in food was not dependent of the chewing speed, the ability of detection differed between slow and fast chewing especially if the number of chews was limited. This further implied that fast chewers who had not chewed their food long enough (say, below the average of 20·7 chews) might have failed to detect a hard foreign object in food and instead swallowed the object, or if they chewed their food longer, they would eventually bite and detect the foreign object. However, with greater momentum, the teeth could have a greater risk of being fractured during the fast jaw closure. On the other hand, chewing food slowly tended to detect the foreign object early in the chewing sequence so the object was likely to be removed and not swallowed. Moreover, the amount of momentum at the time of detection tended to be smaller than that during fast chewing.

In addition, when only the trials without foreign objects were analysed, it was found that the number of chews before swallowing was significantly smaller in slow chewing compared to that in fast chewing. This was probably explained by the increased median particle size (3) and presumably by the reduction of saliva and consequently in bolus cohesiveness as the chewing rate was increased (17). It is not known whether the above relationship would be the same during a habitual meal as it is likely that a hasty person who chews fast would also swallow food sooner. However, when the time before swallowing was analysed, fast chewers still swallowed the food in less time than slow chewers (slow: 40·6/50 = 0·81 min versus fast: 60·2/100 = 0·60 min). The number of chews before swallowing observed in the present study was probably higher than that in real life as our subjects tended to spend more time than usual to ensure no foreign object was present before deciding to swallow the test food.

Conclusion

The study has demonstrated that fast chewers tend to have reduced capability in detecting a hard foreign object in their food and hence, have an increased risk of swallowing the object. Slow chewers, on the other hand, can detect the foreign object more effectively with less number of chews. If the probability of fracturing a tooth is equal for each chew throughout the chewing sequence, slowing chewing might also reduce the chance of tooth fracture caused by accidentally biting on the hard foreign object in food.

Disclosure/Acknowledgments

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