行政院國家科學委員會專題研究計畫　成果報告

活動義齒之軟硬食咀嚼效率評估

計畫類別：個別型計畫
計畫編號：NSC91-2314-B-002-165-
執行期間：91 年 08 月 01 日至 92 年 07 月 31 日
執行單位：國立臺灣大學醫學院口腔生物科學研究所

計畫主持人：蕭裕源

計畫參與人員：彭寶瑤 張育菁 邱信銓

報告類型：精簡報告

處理方式：本計畫可公開查詢

中　華　民　國 92 年 12 月 1 日

行政院國家科學委員會補助專題研究計畫成果報告

※※※※※※※※※※※※※※※※※※※※※※※※※※※※
※　　活動義齒者之軟食咀嚼效率評估: Part one　　※
※　　※
※　Soft food chewing efficiency of
removable denture wearers: Part one　　※
※　　※
※　　※
※※※※※※※※※※※※※※※※※※※※※※※※※※※

計畫類別：☑個別型計畫　　□整合型計畫

計畫編號：NSC 91-2314-B-002-165-

執行期間： 91 年 8 月 1 日至 92 年 7 月 31 日

主持人：蕭裕源 教授　　台灣大學醫學院口腔生物科學研究所

共同主持人：王若松 副教授　台灣大學醫學院牙醫學系

本成果報告包括以下應繳交之附件：

□赴國外出差或研習心得報告一份

□赴大陸地區出差或研習心得報告一份

□出席國際學術會議心得報告及發表之論文各一份

□國際合作研究計畫國外研究報告書一份

執行單位：台灣大學醫學院口腔生物科學研究所

中　華　民　國　92　年　11　月　26　日

行政院國家科學委員會專題研究計畫成果報告

咀嚼效率與功能性咬合面積相關關係之研究

Hard and soft food chewing efficiency of removable denture wearers: Part one

計畫編號：NSC 91-2314-B-002-165

執行期限：91 年 8 月 1 日至 92 年 7 月 31 日

主持人：蕭裕源 教授　　台灣大學醫學院口腔生物科學研究所
共同主持人：王若松 副教授　　台灣大學醫學院牙醫學系

一、中文摘要

咀嚼硬物時下顎運動及咀嚼速率已於本實驗室及國外實驗室中充分研究過，而軟食之咀嚼效率觀測法也已於前年度計畫中研究過。這些研究成果都針對完整齒列者之咀嚼功能，本次研究乃在於使用所創用之含氫氧磷酸鈣(HA)口香糖塊研究完整及缺牙後使用局部活動義齒者之口香糖咀嚼效率。

參與之受測者為年齡自 18 至 25 歲無缺牙且咀嚼肌無疼痛者 14 人(7 男 7 女)，於咀嚼口香糖塊 30 次後, 吐出做切片及觀察切片 X 光影像中 HA 分布之均勻度為其咀嚼效率。另外測取兩名單顎單測無後牙且裝置合適活動義齒之男性病患 2 人進行相同實驗。由於在初步實驗中，發現觀測下顎運動時帶著傳統牙齒夾具的義齒受測者有較不穩定的觀測值，遂優先處理顎運動觀測之矯正，比較皮膚上貼片法及口內夾具法在觀測值上之差異。

結果發現，口內夾具觀測法在最大開口情況時較頦上貼點之運動範圍小，但在下顎運動速度方面率及咀嚼速率方面則無異。帶夾具時口香糖咀嚼效率較僅有頦貼點之咀嚼效率為差。同樣以頦貼點觀測時，戴假牙者之咀嚼效率比有齒列者稍低，但並不顯著。

關鍵詞：口香糖咀嚼，咀嚼效率，頦皮膚貼片，口內夾具， 部分義齒。

Abstract

The chewing efficiency of hard food mastication had been studied in our previous projects, and that of soft food chewing has also been intensively studied in our project of 2001. All the previous studies were on human subjects with complete dentition. The purpose of this study was to apply a hydroxyapatite(HA) containing chewing gum to observe the chewing efficiency of soft food in both complete dentition subjects and subjects with partial removable dentures. Fourteen young subjects (7 males and 7 females, aged from 18 to 25 years old) having complete dentition and healthy TMJ and facial muscles were observed. They were asked to chew an HA containing chewing gum block for 30 times. The gum boluses were then frozen and sectioned and the distribution the HA in a bolus section was observed and compared. Another 2 subjects having missing posterior teeth in one quardant and restored with a unilateral removable partial denture were also observed for comparison. In this report, dental clutch attachment and skin surface marks were applied on each subject during chewing observation. The comparison of measurement accuracy was compared first. It was found that tracing skin mark on the chin showed significantly wider opening range, while not in lateral movement and chewing rate. However, the gum chewing efficiency in subjects with dental clutch was not significantly lower than in subjects with chin marks only. In 30^{th} chewing stroke, 50% HA homogeneity was found. The chewing efficiency of the denture wearers was significantly lower than that of natural

dentition subjects. Based on those findings, it can be concluded that dental clutch may affect the maximum jaw opening movement, but the lateral movement and rhythm and velocity of jaw movement are not affected. The preliminary results also showed that the stability of the denture is the key factor for gum chewing ability. The attachment of dental clutch on lower incisors might cause incomplete sealing of the lips during chewing, while it would not affect the ability of gum chewing significantly.

Keywords: Chewing gum chewing, Chewing efficiency, Dental clutch tracing, Chin marks, Free end denture

I. Introduction

. Many methods have been proposed to observe hard food chewing function, e.g., sieve method (Manly R.S. & Braley L.C., 1950 ; Helkimo E. et al, 1978), colorimetric analysis (Kayser A.F. & van der Hoeven J.S., 1977), photometric analysis (Nakasima A., 1989), and computer image analysis methods (Shi C.S., 1990 ; Mowlana F. et al, 1995) etc. Among them, sieve method was more often used for hard foods like peanuts or almonds. It was generally believed that the wider the occlusal contact area, the higher the chewing efficiency (Lambercht J.R., 1965). The linear correlation was said to be high. However, similar correlation was not found in soft food chewing.

Soft foods like agar or “toufu” can be “chewed” without using teeth (Arai E. & Yamada Y.1993). Human subjects without teeth can do as good as completely dentate subjects. However, soft food like chewing gum is chewed for fun without swallowing it. The ability of mixing the ingredients of the chewing gum after chewing has been regarded as the chewing efficiency of gum chewing (Liedberg B. & Owall B., 1995; Matsui Y. et al, 1995; Prinz J.F., 1999). Our previous studies on gum chewing concluded that presence of teeth is necessary for gum chewing, but bite force does not strongly related to the gum chewing function. However, when the missing area was restored with removable partial denture, the occlusal area was restored while the retention and stability of the denture might not be sufficient for gum chewing. The effects of such condition on gum chewing efficiency have not been well documented.

However, in a pilot study of chewing gum chewing of a patient with a mandibular class II removable partial denture, the recording of the jaw movement was uncertain because of the unstable clutch attachment on the denture. Therefore, establishment of a clutch-free observation system became more urgent. The present report is the outcomes of such pilot study.

II. Materials and methods

1. Fabrication of standardized soft test foods：

Fresh sugarless chewing gum, Extra (Wrigley’s sugar free chewing gum 7.2×1.8 cm), was used as base material of the test food. The gum strip was equally divided into three parts with two depression lines. In the

center of the middle part, a 0.5 cm diameter depression was formed with a round wood stick. In the depression, 0.02 g HA particles (Hydroxylapatite, HA, Calcitite 4060-2, Calcitek, 40-60 mesh, Sulzer, Carlsbad, CA, USA) were inserted. The two side parts were then folded on top and bottom of the central part with a gentle pressure. The border of the three-layered gum blocks was sealed by finger pressure. The HA containing gum blocks were then stored in a 20℃ incubator before use.

2. Subjects：

Fourteen subjects with complete dentition (7 males, and 7 females, aged from 18 to 25 years) were included as the complete dentition group. They had no missing teeth except third molars. No evident TM joint and masticatory muscle pain or dysfunction during and before examination was found. Another two patients (two males, aged 45 and 60 years) who had unilateral free-end removable partial dentures in the lower jaw were served as denture group. A RPI clasp was applied on the distal abutment which was sound in periodontal support. They did not have TMJ and muscle problems either. Both of the two group subjects were well informed with the procedures of this human experiment. The research protocol was approved by the committee of medical ethics of the National Taiwan University Hospital.

3. Jaw movement observation system: Vicon system was applied for the observation of jaw movement. There were five cameras hanged from the ceiling with equal distance among each other and from the head of the subject who was sitting upright on a stool without a head- rest. The five cameras were hanged 2.0m above the head level at 45degree angles.

Four face marks (3.0mm in diameter) were attached on the skin surface of frontal, bilateral, zygomas and chin points with adhesive glue. A dental clutch was attached to the lower incisor with self-cure resin and quick set glue. A metal extension from the clutch was 2 cm long. The tip of the extension had cross-shape metal bars and four marks were attached to the ends of the cross. All the tracks formed during jaw movements and gum chewing were recorded and analyzed by the Vicon system with Matlab version 6.5 (Mathworks Inc, USA).

4. Evaluation of chewing efficiency：

Based on our previous study, 20 chewing cycles for chewing gum chewing produced more than 40% homogeneity of HA particle distribution (Table 1) For time saving and more comparable chewing observation, 30 chewing cycle procedure was selected. The subject was asked to chew a chewing gum block firstly with his / her habitual side teeth and then the non-habitual side teeth 30 times respectively. The chewed gum bolus after each chewing session was spat out and immersed in a glass of ice water. Before spitting out, the gum bolus was roughly rounded by the subject with his / her tongue, teeth and lips.

A pin was inserted in the approximate center of the chilled gum bolus, which was

then embedded in a self-cure resin block (Temporon, GC Corporation. Tokyo, Japan). The gum bolus containing resin block was then sectioned with a low speed saw (Isomet, Buehler Co. Ltd. Illinois, USA) on a reference plane parallel to the pin. The middle most section of 0.5 mm thickness was obtained for radiography. A digital X-ray system (Digora digital image system, Soredex Orion Co., Helsinki, Finland) was used to obtain the image. The HA particles were found in the film of that section. The number of cells containing one or more HA particles was divided by total cell numbers covering the chewing gum section, and was regarded as the percentage of HA homogeneity in that section of gum or the chewing efficiency of that subject at that chewing session.

5. Statistical treatment：

Data of mandibular border movement, chewing movement and chewing efficiency obtained from each group were analyzed and compared with ANOVA and paired t test. Significance level was set at $P<0.05$.

III. Results

Maximum opening movement without clutch was slightly wider than with clutch in complete dentition group ($P<0.05$). Such difference in denture group was not as significant. However, the difference between two measurement ways in lateral movement was not significant in both natural and denture conditions ($P>0.05$; Table 1). The distance change of chin mark during chewing with and without dental clutch attachment showed non-significant difference (16.84+/- 6.69 vs.14.22+/-4.07, $P>0.05$). However, chewing displacement of the jaw with clutch only and with chin mark only showed significant difference (14.22+/-4.07 vs. 19.50+/-4.83, $P<0.05$). The chewing rate with dental clutch was slightly faster than with chin mark only, but the difference was not significant (26.76 vs. 24.21, $P>0.05$). Chewing efficiency in complete dentition group was in general better than in denture group, but the difference was not significant between chewing with clutch and chewing without clutch ($P>0.05$).

IV. Discussion

In our previous studies, we found that only weak correlation existed between occlusal contact area and chewing gum chewing efficiency. It can be concluded that gum chewing does not require wide dental occlusal area. The lack of teeth can also be regarded as the major loss of occlusal contact area which in turn would minimize the platform for pulverizing and squeezing activities with the help of the tongue and check. In our studies, no observation was made on the effects of tongue movement on gum chewing efficiency.

The findings on significantly wider jaw maximum opening in chin mark observation might be due to the extension of the skin at the chin area during wide opening. During

the late stage of maximum opening, the suprahyoid muscles pull the chin downward and backward and the skin of the chin point is also extended. The chin mark is thus moved more downward and backward than the mandible itself. The findings on the non-significant difference in chewing efficiency between dental clutch attachment and chin mark attachment observation methods suggested that lip sealing during gum chewing is not necessary. Subjects with complete dentition can chew the chewing gum with or without lip closure. However, when the chewer is a denture wearer, clutch attachment might jeopardize the stability of the denture, or at least the worry of such instability, thus the chewing efficiency was reduced.

Based on this preliminary result, it can be postulated that if lip sealing is important, dental clutch observation method would be less physiological. Facial mark observation technique should be more practical if the motion is not too wide. However, details of the jaw movements during chewing might not be represented by the skin marks motion. The sensitivity of the tracking system as well as the flexibility of the attached skin should be carefully evaluated before drawing a conclusion.

Acknowledgement

This study was support by the National Science Council of the Republic of China with a Grand of NSC 91-2314-B002-165. The Vicon system installed in the Medical Engineering Institute of National Taiwan University and the staff led by Professor T.W. Lu provided instrument and technique for this study. They are highly appreciated.

V. References

1. Arai, E. and Yamada, Y. (1993). Effect of the texture of food on the masticatory process. Japanese J Oral Biol 35, 312.
2. Hayakawa, I., Watanabe, I., Hirano, S., Nagao, M. and Seki, T. (1998). A simple method for evaluating masticatory performance using a color-changeable chewing gum. Int J Prosthodont 11, 173-176.
3. Helkimo, E., Carlsson, G.E. and Helkimo, M. (1978). Chewing efficiency and state of dentition. A methodologic study. Acta Odontol Scand 36, 33-41.
4. Kayser, A.F. and Van Der Hoeven, J.S. (1977). Colorimetric determination of the masticatory performance. J Oral Rehabil 4, 145-148.
5. Kayser, A.F. (2000). Limited treatment goals-shortened dental arches. Periodontology 2000 (1994) 4:7-14.
6. Lambrecht, J.R. (1965). The influence of occlusal contact area on chewing performance. J Prosthet Dent 15, 444-450.
7. Liedberg, B. and Owall, B. (1995). Oral bolus kneading and shaping measured with chewing gum. Dysphagia 10, 101-106.
8. Manly, R.S. and Braley, L.C. (1950). Masticatory performance and efficiency. J Dent Res 29, 448.
9. Matsui, Y., Neukam, F.W., Wichmann, M. and Ohno, K. (1995). Application of a low-adhesive color-developing chewing

gum system to patients with osseointegrated implant-supported prostheses. Int J Oral Maxillofac Implants 10, 583-588.
10. Mowlana, F., Heath, M.R. and Auger, D. (1995). Automated optical scanning for rapid sizing of chewed food particles in masticatory tests. J Oral Rehabil 22, 153-158.
11. Nakasima, A., Higashi, K., and Ichinose, M. (1989). A new, simple and accurate method for evaluating masticatory ability. J Oral Rehabil 16, 373-380.
12. Prinz, J.F. (1999). Quantitative evaluation of the effect of bolus size and number of chewing strokes on the intra-oral mixing of a two-colour chewing gum. J Oral Rehabil 26, 243-247.
13. Seligman, D.A., Pullinger, A.G. (1988). TMJ derangement and osteoarthrosis subgroups differentiated according to active range of mandibular opening. J Craniomandib Disord 2, 33-40.
14. Shi, C-S, Ouyang, G. and Guo, T-W (1990). Masticatory efficiency determined with direct measurement of food particles masticated by subjects with natural dentitions. J Prosthet Dent 64, 723-726.
.

Table 1. Chewing efficiency of complete and incomplete dentition subjects

(Data obtained in 2001)

	Complete dentition		Incomplete dentition	
Stroke	**Habitual**	**Non-habitual**	**Habitual**	**Non-habitual**
10	**20.9±6.7**	**21.2±6.0**	**20.5±5.1**	**18.1±4.8**
15	**30.7±4.7**	**33.3±6.0**	**34.6±5.1***	**28.6±6.9***
20	**41.9±6.8#**	**40.1±6.5▼**	**43.9±3.5***	**33.6±7.9*#▼**
25	**48.5±5.7#**	**49.2±5.3▼**	**51.0±4.8***	**42.6±5.3*#▼**
30	**54.6±4.7**	**55.9±5.6**	**54.2±7.7**	**52.1±5.7**

* $P < 0.05$ between incomplete dentition habitual and non-habitual side.

\# $P < 0.05$ between complete dentition habitual side and incomplete non-habitual side.

▼ $P < 0.05$ between complete dentition non-habitual side and incomplete non-habitual side.

¥ Non-habitual of incomplete dentition was the side of missing teeth.

Table 2. Maximum opening ability in dentate and denture subjects

Subjects	**MMO w/o clutch**	**MMO w/ clutch**
Natural	**50.03±9.78**	**48.75± 11.61**
Denture	**53.1±40.40**	**46.42± 3.50**
	Observation on chin mark	**Observation on dental clutch**
Natural	**48.75± 11.61**	**43.68± 7.65**
Denture	**46.42± 3.50**	**44.58± 3.77**

Table 3. Lateral border movement with and without dental clutch

Border Movement	w/o clutch	w/ clutch
Natural dentate	20.40±11.24	21.76±10.84
RPD wearers	18.19±2.30	13.07±1.71
Border movement with clutch	**On chin mark (w/clutch)**	**On clutch mark(w/clutch)**
Natural dentate	21.76±10.84	20.76±9.29
RPD wearers	13.07±1.71	7.87±1.51

Table 4 Jaw movement observed on chin mark during gum chewing w/ and w/o clutch attachment

Subjects	Chew w/ clutch	Chew w/o clutch
Natural	14.22±4.07	16.84±6.69
Denture, natural side	8.86±1.23	17.78±5.44
Denture, denture side	10.50±5.20	19.82±5.76

Table5. Jaw position change during chewing observed on chin mark and clutch mark

Subjects	Chin mark	Clutch mark
Natural	16.48±6.69	19.50±4.83
Denture, natural side	17.78±5.44	17.63±5.96
Denture, denture side	19.82±5.76	19.16±7.35

Figures

Fig. 1 Ingredients of the standardized test food

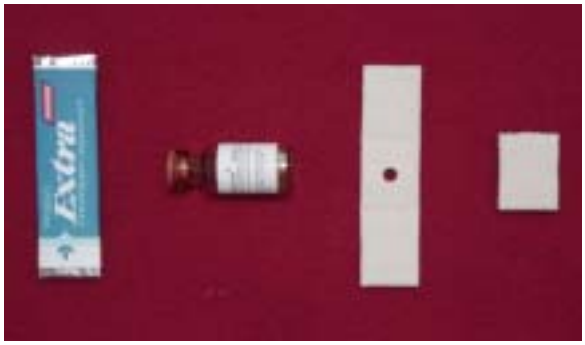

Fig. 2 Occlusal contact force shown with Photoimpact on the PCmonitor

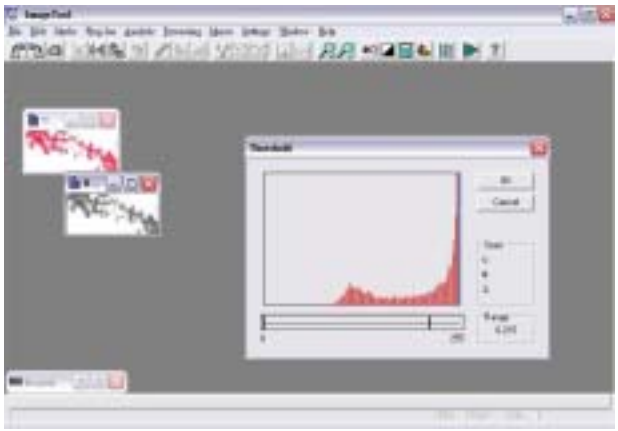

Fig. 3 Sectioned gum bolus showing HA particles in a X-ray film and under a 100 cell overlay.

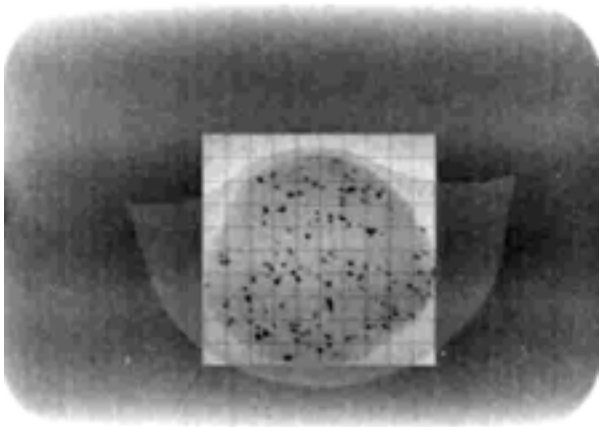

Fig. 4 Chewing efficiency of complete dentition subjects with habitual and non-habitual side teeth

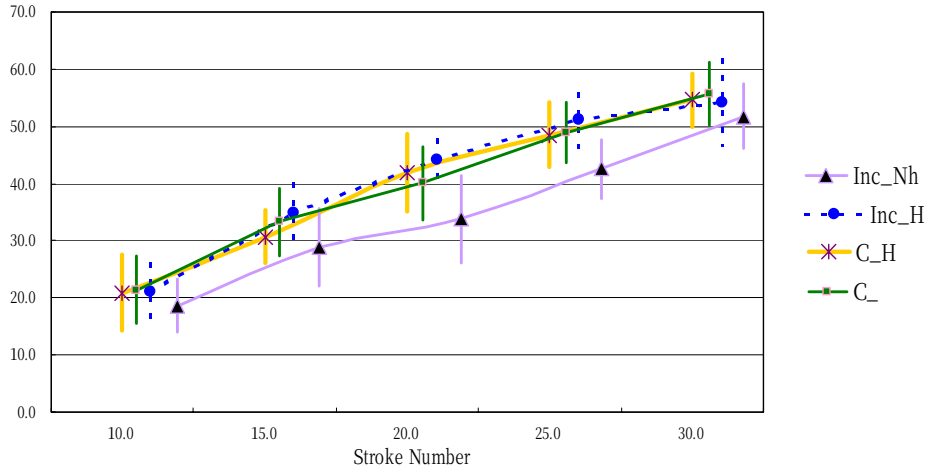

Fig. 5 3D tracing of the chin during border movement

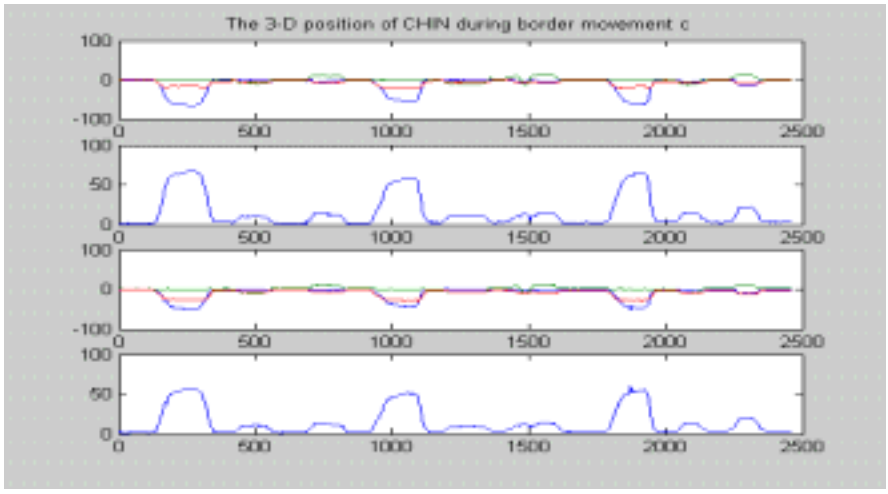

Fig. 6 3D position of the chin during chewing

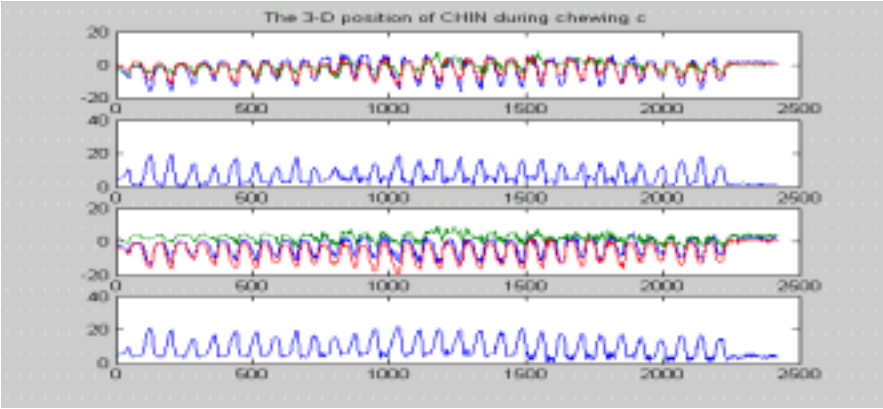

Fig.7 Chewing efficiency of complete dentition subjects with chin mark and dental clutch