Original report

## Comparisons of Masticatory Movements while Wearing Complete Mandibular Dentures with and without Suction in a Totally Edentulous Subject

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# Prosthodontics

**Comparisons of Masticatory Movements while** Wearing Complete Mandibular Dentures with and without Suction in a Totally Edentulous Subject

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The same edentulous subject was allowed to wear both complete mandibular dentures with and without suction to compare the differences in masticatory movements that were measured with the Gnatho-Hexagraph II, a device for measuring mandibular movement.

The following improvements were shown in all chewing patterns of right-lateral and left-lateral chewing and free chewing while wearing the complete mandibular dentures with suction compared to wearing dentures without suction.

1) Reduction in mouth opening-closing time

2) Increase in the range of mouth opening

3) Improvement in chewing rate

4) Improvement in stability of chewing rhythm

The values measured were closer to those of masticatory movements in healthy dentulous persons. Thus, the masticatory movements while wearing the complete mandibular dentures with suction seemed to be physiologically and efficiently executed.

Key words: complete mandibular dentures with suction, masticatory movement, Gnatho-Hexagraph II

## I. Introduction

As we know from history of constructing complete dentures, rivalries and trials have been repeated to test techniques in order to reach goals so that a maxillary denture should not drop with suction effect, that a mandibular denture would be used for stable mastication even though suction is incomplete, and that a denture would not cause any pain to work <sup>1</sup>). Current understanding might almost confirm that those goals are nearly met with thanks to efforts of our forerunners who advanced to develop new materials, theories and techniques.

In this regard, next future attention will be on the issue of the

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complete mandibular denture suction.

Reasons for difficult stability of the lower denture might be, in addition to its limited denture bearing area of residual ridge <sup>2, 3)</sup>, remarkable tongue mobility in the mouth, and extensively mobile mucobuccal fold during the course of mouth opening-closing which is said to become 2-3 times larger than that of maxillary jaw<sup>4)</sup>.

In 1999, Abe presented that the denture base suction of the complete mandibular denture would be achieved equally like that of maxillary denture, when the denture base border could be totally sealed with the mobile soft tissues. And he rationalized and published on the suction mechanism of the complete mandibular denture for the first time in the profession over the world<sup>5</sup>. This clinical technique has been introduced via various media of information since then and has been going popular



Fig.1 Subject A (Healthy dentulous subject) and Subject B (Edentulous patient).

nationwide presently <sup>6-10</sup>. In practice, if a complete denture is constructed accordingly as based on this theory, the suction will become certainly effective in many cases of lower complete dentures. And also because patients' responses to wearing are commonly favorable, the complete mandibular denture suction can be used as well like in practice of a maxillary denture in order to reduce denture mobility and to prevent the denture from dislodging or toppling. But it is admitted, however, that no scientific reports have been made to confirm this effectiveness.

Thus, the aim of this study was to verify favorable wearing responses of mastication objectively and to compare the differences of masticatory movements of same patient wearing a complete mandibular denture respectively with suction or without suction with the aid of a diagnosing device of three dimensional 6 degrees of freedom jaw movement analysis. And interesting results will be reported here.

### **II. Research Method and Materials**

#### 1. Subjects and Test food (Fig.1-3)

Subject A: A healthy dentulous female subject exhibiting no abnormal temporomandibular joints from clinical and radiographic views. Age of 22 years and established as control (Hereafter called as C).

Macroscopic observation reveals straight and smooth traces of frontal plane jaw opening and closing pathways <sup>11</sup>). Radiographic view confirms no problems on the head of mandible position within the TMJ fossa or its form, or right and left jaw movement synchronism and its range of motion <sup>12, 13)</sup>.

Subject B: A maxillo-mandibulary edentulous male

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Fig.2 Intraoral photographs of Subject A and B.

subject likewise exhibited no abnormal temporomandibular joints from clinical and radiographic views. Age of 81 years, and showed slightly better than medium degree of residual ridge condition on both jaws.

Test food: Cubical pieces of fish sausage in size of about 1cm on a side.

#### 2. Method of Masticatory movement

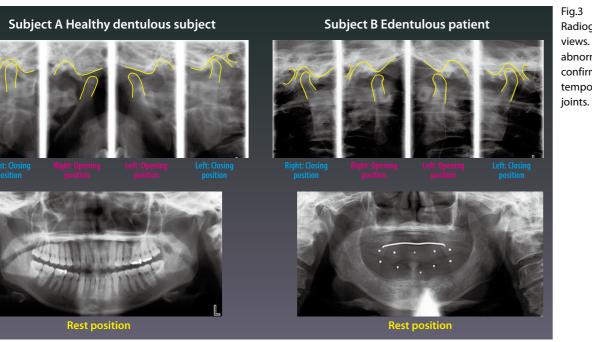
Both subjects were instructed to chew the test pieces in three different patterns of chewing such as the right-lateral chewing, the left-lateral chewing and the free chewing. Cycles of motion were tried in 10 strokes each for the right-lateral and the leftlateral, and in 20 strokes for the free chewing.

As for the subject B, these strokes were tested in wearing both complete mandibular dentures without suction (hereafter called as D1) and with suction (hereafter called as D2) (Fig.4). Opposing complete maxillary dentures are confirmed effective with suction when tested respectively.

#### 3. Masticatory movement pathways and velocity measurements

With the help of the mandibular jaw movement measuringdevice, Gnatho-Hexagraph II (G-C Corp), three dimensional 6 degrees of freedom movement pathways and velocity measurements were determined.

A stereo camera system assembled with two high speed CCD cameras was organized to take an LED photographing (lightemitting diode) joined with a subject head (head frame) and a mandibular jaw (facebow). Then an exclusive high-speed image



Radiographic views. No abnormalities were confirmed in the temporomandibular

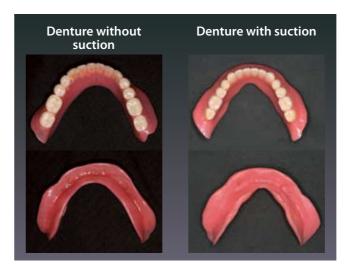


Fig.4 Tested complete mandibular dentures of Subject B.

processing unit incorporated within the stereo camera system employed the stereo image processing including the processed corresponding points on the basis of actual time. And processed data of relative motion of mandibular jaw against maxillary jaw were computed.

Each head frame and facebow has three LED lights at prescribed positions. As for the subject B, the facebow was attached to the complete mandibular denture.

4. Measurement items and method of analysis
1) Time factors

- (1) Mouth opening-closing time
- (2) Mouth opening time
- (3) Mouth closing time
- (4) Occlusion time
- 2) Mandibular jaw movement pathways

(1) Magnitude of mouth opening at maximal opening point

- 3) Mandibular jaw movement velocity
- (1) Maximal velocity at mouth opening
- (2) Maximal velocity at mouth closing

In this analysis the first stroke sequence of measurement was excluded because it likely permitted errors. Mean values of individual strokes were calculated from measurement items and were comparatively studied.

4) Masticatory rhythm and masticatory pattern

## III. Research results (Fig5, Table1)

#### 1. Time factors

As for the mouth opening-closing time, the results were obtained in the order of C<D2<D1. For details, D2 showed shorter duration than D1 in almost all cases of factors, but only in the case of the right-lateral and free chewing time, results were reverse.

#### 1) Mouth opening-closing time

	All patterns of chewing	C <d2<d1< td=""></d2<d1<>
2) Mouth opening time	Right-lateral chewing	C <d2<d1< td=""></d2<d1<>
	Left-lateral chewing	D2 <d1<c< td=""></d1<c<>
	Free chewing	C <d2<d1< td=""></d2<d1<>
3) Mouth closing time	Right-lateral chewing	D2 <c<d1< td=""></c<d1<>
	Left-lateral chewing	C <d2<d1< td=""></d2<d1<>
	Free chewing	C <d2<d1< td=""></d2<d1<>
4) Occlusion time	Right-lateral chewing	D1 <c<d2< td=""></c<d2<>
	Left-lateral chewing	C <d2<d1< td=""></d2<d1<>
	Free chewing	C <d1<d2< td=""></d1<d2<>

#### 2. Mandibular jaw movement pathways

Larger distance of traces exhibited in all cases of chewing with D2 in comparison with D1.

1) Magnitude of mouth opening at maximal opening point

Right-lateral chewing	C <d2<d1< td=""></d2<d1<>
Left-lateral chewing	C <d2<d1< td=""></d2<d1<>
Free chewing	D2 <c<d1< td=""></c<d1<>

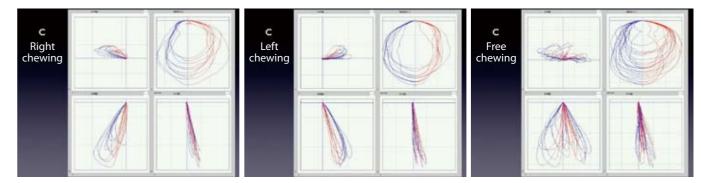


Fig.5-2 Subject A (Dentulous healthy subject).

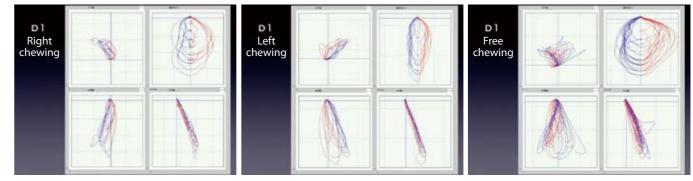


Fig.5-3 Subject B (Edentulous patient) Complete mandibular denture without suction.

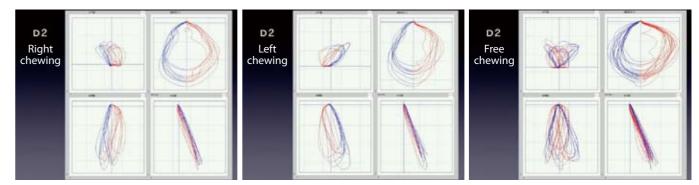


Fig.5-4 Subject B (Edentulous patient) Complete mandibular denture with suction.

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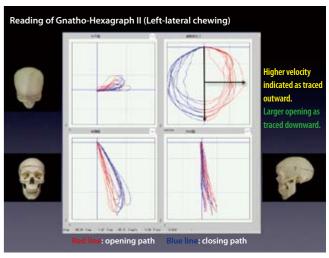


Fig.5-1 Subject A (Dentulous healthy subject) indicated [C], Of Subject B (Edentulous patient), Wearing the complete mandibular denture without suction [D1] and with suction [D2].

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Stroke Oper	ning-closing time	Occlusion	Opening	Closing	Opening maximal	Closing maximal	Opening	Table 1-1 Movement analysis of mouth   Table 1-4 Movement analysis of mouth	Stroke Ope		Occlusion	Opening time	Closing	Opening maximal	Closing maximal	Opening
1	0.838	time 0.146	' time 0.383	timé 0.308	velocity 113.501	velocity 93.125	magnitude 18.784	opening-closing. opening-closing.	1	time 4.279	time 1.296	2.704	timē 0.279	velocity 53.091	velocity 101.977	magnitude 13.511
1 2	0.838	0.146	0.385	0.308	119.261	79.896	16.764	Subject A, Dentulous healthy subject Subject B, Wearing the complete mandibular	2	4.279 0.821	0.233	0.363	0.279	71.974	85.646	14.542
2	0.704	0.238	0.173	0.292	91.625	85.463	14.306	Name: C denture without suction	2	0.821	0.233	0.333	0.223	116.281	99.114	14.542
4	0.633	0.292	0.172	0.263	113.132	73.701	15.264	Data classification: Right chewing Name: D1	4	0.871	0.192	0.354	0.325	88.601	96.101	19.42
5	0.625	0.167	0.217	0.203	100.365	96.807	18.023	Data classification: Right chewing	5	0.938	0.204	0.375	0.358	107.659	92.07	21.009
6	0.708	0.246	0.208	0.254	114.134	90.962	18.088		6	0.792	0.246	0.167	0.379	86.498	92.534	10.871
7	0.75	0.246	0.196	0.308	180.938	129.95	23.238		7	0.875	0.258	0.379	0.238	79.852	84.308	17.29
8	0.804	0.329	0.213	0.263	146.278	135.599	21.947		8	0.996	0.213	0.371	0.413	97.692	91.56	20.139
9	0.679	0.175	0.221	0.283	111.573	91.86	19.497		9	0.879	0.15	0.421	0.308	85.736	37.875	13.795
10	1.121	0.492	0.292	0.338	143.368	97.436	21.567		10	0.746	0.121	0.354	0.271	69.127	103.776	15.815
Ave (2-10)	0.748	0.264	0.210	0.274	124.519	97.964	18.476		Ave (2-10)	0.864	0.204	0.346	0.313	89.269	86.998	16.710
	(sec)	(sec)	(sec)	(sec)	(mm/sec)	(mm/sec)	(mm)			(sec)	(sec)	(sec)	(sec)	(mm/sec)	(mm/sec)	(mm)
								Table 1-2 Movement analysis of mouth	Stroke Ope	ning-closing	Occlusion	Opening time	Closing	Opening maximal	Closing maximal	Opening magnitude
Stroke Oper	ning-closing	Occlusion time	Opening time	Closing time	Opening maximal velocity	Closing maximal velocity	Opening magnitude	Opening-ciosing.		time	time		time	velocity	velocity	
1	0.842	0.15	0.367	0.325	119.198	82.268	20.631	opening-closing. Subject B, Wearing the complete mandibular	1	0.896	0.317	0.371	0.208	13.925	25.45	3.738
2	0.667	0.188	0.233	0.246	114.22	122.054	20.934	Subject A, Dentulous healthy subject denture without suction	2 3	0.942 0.825	0.438 0.358	0.288 0.246	0.217 0.221	39.768 70.216	37.635 61.809	7.117 9.313
3	0.675	0.175	0.258	0.242	123.867	140.947	22.843	Name: C Name: D1	5 4	0.825	0.358	0.246	0.221	56.764	53.658	9.515
4	0.746	0.233	0.271	0.242	88.873	108.47	19.6	Data classification: Loft chowing	4 5	0.955	0.438	0.240	0.229	61.612	52.234	10.609
5	0.588	0.179	0.221	0.188	99.948	133.425	17.654	Data classification: Left chewing Data classification: Left chewing	5	0.805	0.4	0.229	0.233	81.048	57.932	11.246
6	0.708	0.246	0.246	0.217	102.672	131.41	18.082		7	0.842	0.388	0.229	0.225	44.252	56.437	8.928
7	0.671	0.196	0.217	0.258	157.966	127.938	21.956		8	0.813	0.342	0.242	0.229	61.592	51.168	9.832
8	0.758	0.313	0.246	0.2	113.457	141.031	20.877		9	0.875	0.413	0.221	0.242	77.408	50.835	10.357
9	0.717	0.233	0.267	0.217	104.946	147.664	21.565		10	0.758	0.388	0.154	0.212	58.841	63.47	7.646
10	0.808	0.333	0.258	0.217	109.11	141.936	21.05		Ave (2-10)	0.858	0.390	0.240	0.229	61.278	53.909	9.469
Ave (2-10)	0.704	0.233	0.246	0.225	112.784	132.764	20.507		- ( - )							
		0.200	0.210	0.225	112.704	152.704	20.507			(sec)	(sec)	(sec)	(sec)	(mm/sec)	(mm/sec)	(mm)
	(sec)	(sec)	(sec)	(sec)	(mm/sec)	(mm/sec)	(mm)			(sec)	(sec)	(sec)	(sec)	(mm/sec)	(mm/sec)	(mm)
	(sec)							Table 1-6 Movement analysis of mouth	Stroke Ope	ning-closing	Occlusion		Closing	Opening maximal	Closing maximal	
Stroka Open		(sec)	(sec)	(sec)	(mm/sec)	(mm/sec)	(mm)		Stroke Ope	ning-closing time	Occlusion time	Opening time	Closing time	Opening maximal velocity	Closing maximal velocity	Opening magnitude
Stroke Oper					(mm/sec) Opening maximal	(mm/sec)	(mm)	Table 1-3 Movement analysis of mouth opening-closing.	1	ning-closing time 0.658	Occlusion time 0.163	Opening time 0.358	Closing time 0.138	Opening maximal velocity 34.044	Closing maximal velocity 69.934	Opening magnitude 6.068
Stroke Oper		(sec) Occlusion	(sec)	(sec)	(mm/sec)	(mm/sec)	(mm)	Table 1-3 Movement analysis of mouth   opening-closing.     opening-closing.   Subject B, Wearing the complete mandibular	1 2	ning-closing time 0.658 0.708	Occlusion time 0.163 0.208	Opening time 0.358 0.213	Closing time 0.138 0.288	Opening maximal velocity 34.044 70.102	Closing maximal velocity 69.934 39.28	Opening magnitude 6.068 8.503
Stroke Oper 1 2	ning-closing time	(sec) Occlusion time	(sec) Opening time	(sec) Closing time	(mm/sec) Opening maximal velocity	(mm/sec) Closing maximal velocity	(mm) Opening magnitude	Table 1-3 Movement analysis of mouth opening-closing.   opening-closing.     opening-closing.   Subject B, Wearing the complete mandibular denture without suction     Subject A, Dentulous healthy subject   denture without suction	1 2 3	ning-closing time 0.658 0.708 0.746	0cclusion time 0.163 0.208 0.275	Opening time 0.358 0.213 0.233	Closing time 0.138 0.288 0.238	0pening maximal velocity 34.044 70.102 86.702	Closing maximal velocity 69.934 39.28 62.698	Opening magnitude 6.068 8.503 11.159
1	ning-closing time 0.671	(sec) Occlusion time 0.071	(sec) Opening time 0.383	(sec) Closing time 0.217	(mm/sec) Opening maximal velocity 90.768	(mm/sec) Closing maximal velocity 144.345	(mm) Opening magnitude 21.503	Table 1-3 Movement analysis of mouthopening-closing.opening-closing.Subject B, Wearing the complete mandibularSubject A, Dentulous healthy subjectdenture without suctionName: CName: D1	1 2 3 4	ning-closing time 0.658 0.708 0.746 0.746	0cclusion time 0.163 0.208 0.275 0.229	0pening time 0.358 0.213 0.233 0.204	Closing time 0.138 0.288 0.238 0.313	0pening maximal velocity 34.044 70.102 86.702 62.024	Closing maximal velocity 69.934 39.28 62.698 51.45	Opening magnitude 6.068 8.503 11.159 8.552
1 2	ning-closing time 0.671 0.55	(sec) Occlusion time 0.071 0.167	(sec) Opening time 0.383 0.167	(sec) Closing time 0.217 0.217	(mm/sec) Opening maximal velocity 90.768 148.807	(mm/sec) Closing maximal velocity 144.345 106.86	(mm) Opening magnitude 21.503 18.592	Table 1-3 Movement analysis of mouth opening-closing.   opening-closing.     opening-closing.   Subject B, Wearing the complete mandibular denture without suction     Subject A, Dentulous healthy subject   denture without suction	1 2 3	ning-closing time 0.658 0.708 0.746 0.746 0.767	0cclusion time 0.163 0.208 0.275 0.229 0.379	Opening time 0.358 0.213 0.233 0.204 0.175	Closing time 0.138 0.288 0.238 0.313 0.213	0pening maximal velocity 34.044 70.102 86.702 62.024 66.09	Closing maximal velocity 69.934 39.28 62.698 51.45 46.423	0pening magnitude 6.068 8.503 11.159 8.552 6.987
1 2 3	ning-closing time 0.671 0.55 0.596 0.658 0.567	(sec) Occlusion time 0.071 0.167 0.221 0.267 0.117	(sec) Opening time 0.383 0.167 0.163 0.171 0.175	(sec) Closing time 0.217 0.217 0.213 0.221 0.275	(mm/sec) 0pening maximal velocity 90.768 148.807 165.362 110.101 128.281	(mm/sec) Closing maximal velocity 144.345 106.86 119.8 82.813 88.252	(mm) Opening magnitude 21.503 18.592 19.319 14.907 16.516	Table 1-3 Movement analysis of mouth opening-closing.   opening-closing.     opening-closing.   Subject B, Wearing the complete mandibular denture without suction     Subject A, Dentulous healthy subject   Name: D1     Name: C   Data closification: From showing	1 2 3 4	ning-closing time 0.658 0.708 0.746 0.746 0.767 0.679	0cclusion time 0.163 0.208 0.275 0.229 0.379 0.242	Opening time 0.358 0.213 0.233 0.204 0.175 0.225	Closing time 0.138 0.288 0.238 0.313 0.213 0.213	0pening maximal velocity 34.044 70.102 86.702 62.024 66.09 58.922	Closing maximal velocity 69.934 39.28 62.698 51.45 46.423 60.36	0pening magnitude 6.068 8.503 11.159 8.552 6.987 9.973
1 2 3	hing-closing time 0.671 0.55 0.596 0.658 0.567 0.604	(sec) 0cclusion 0.071 0.167 0.221 0.267 0.117 0.158	(sec) Opening time 0.383 0.167 0.163 0.171 0.175 0.192	(sec) Closing time 0.217 0.217 0.213 0.221 0.275 0.254	(mm/sec) 0pening maximal velocity 90.768 148.807 165.362 110.101 128.281 173.556	(mm/sec) Closing maximal velocity 144.345 106.86 119.8 82.813 88.252 119.809	(mm) Opening magnitude 21.503 18.592 19.319 14.907 16.516 21.46	Table 1-3 Movement analysis of mouth opening-closing.   opening-closing.     opening-closing.   Subject B, Wearing the complete mandibular denture without suction     Subject A, Dentulous healthy subject   Name: D1     Name: C   Data closification: From showing	1 2 3 4	ning-closing time 0.658 0.708 0.746 0.746 0.746 0.767 0.679 0.833	Occlusion time       0.163       0.208       0.275       0.229       0.379       0.242       0.292	Opening time 0.358 0.213 0.233 0.204 0.175 0.225 0.246	Closing time 0.138 0.288 0.238 0.238 0.213 0.213 0.213 0.296	0pening maximal velocity 34.044 70.102 86.702 62.024 66.09	Closing maximal velocity 69.934 39.28 62.698 51.45 46.423 60.36 63.741	0pening magnitude 6.068 8.503 11.159 8.552 6.987 9.973 10.161
1 2 3 4 5	hing-closing time 0.671 0.55 0.596 0.658 0.567 0.604 0.75	(sec) 0cclusion 0.071 0.167 0.221 0.267 0.117 0.158 0.163	(sec) Opening time 0.383 0.167 0.163 0.171 0.175 0.192 0.158	(sec) Closing time 0.217 0.217 0.213 0.221 0.275 0.254 0.429	(mm/sec) 0pening maximal velocity 90.768 148.807 165.362 110.101 128.281 173.556 140.534	(mm/sec) Closing maximal velocity 144.345 106.86 119.8 82.813 88.252 119.809 58.203	(mm) Opening magnitude 21.503 18.592 19.319 14.907 16.516 21.46 15.228	Table 1-3 Movement analysis of mouth opening-closing.   opening-closing.     opening-closing.   Subject B, Wearing the complete mandibular denture without suction     Subject A, Dentulous healthy subject   Name: D1     Name: C   Data closification: From showing	1 2 3 4 5 6 7	ning-closing time 0.658 0.708 0.746 0.746 0.767 0.679	0cclusion time 0.163 0.208 0.275 0.229 0.379 0.242 0.292 0.183	Opening time 0.358 0.213 0.233 0.204 0.175 0.225 0.246 0.225	Closing time 0.138 0.288 0.238 0.238 0.213 0.213 0.213 0.296 0.246	0pening maximal velocity 34.044 70.102 86.702 62.024 66.09 58.922 78.451 95.445	Closing maximal velocity 69.934 39.28 62.698 51.45 46.423 60.36 63.741 52.674	0pening magnitude 6.068 8.503 11.159 8.552 6.987 9.973 10.161 10.059
1 2 3 4 5 6 7 8	hing-closing time 0.671 0.55 0.596 0.658 0.567 0.604 0.75 0.55	(sec) 0cclusion 0.071 0.167 0.221 0.267 0.117 0.158 0.163 0.258	(sec) Opening time 0.383 0.167 0.163 0.171 0.175 0.192 0.158 0.138	(sec) Closing time 0.217 0.217 0.213 0.221 0.275 0.254 0.429 0.154	(mm/sec) 0pening maximal velocity 90.768 148.807 165.362 110.101 128.281 173.556 140.534 170.661	(mm/sec) Closing maximal velocity 144.345 106.86 119.8 82.813 88.252 119.809 58.203 141.654	(mm) Opening magnitude 21.503 18.592 19.319 14.907 16.516 21.46 15.228 18.051	Table 1-3 Movement analysis of mouth opening-closing.   opening-closing.     opening-closing.   Subject B, Wearing the complete mandibular denture without suction     Subject A, Dentulous healthy subject   Name: D1     Name: C   Data closification: From showing	1 2 3 4 5 6 7 8	ning-closing time 0.658 0.708 0.746 0.746 0.767 0.679 0.833 0.654	Occlusion time       0.163       0.208       0.275       0.229       0.379       0.242       0.292	Opening time 0.358 0.213 0.233 0.204 0.175 0.225 0.246	Closing time 0.138 0.288 0.238 0.238 0.213 0.213 0.213 0.296	0pening maximal velocity 34.044 70.102 86.702 62.024 66.09 58.922 78.451	Closing maximal velocity 69.934 39.28 62.698 51.45 46.423 60.36 63.741	0pening magnitude 6.068 8.503 11.159 8.552 6.987 9.973 10.161
1 2 3 4 5 6 7 8 9	ning-closing time 0.671 0.55 0.596 0.658 0.567 0.604 0.75 0.55 0.55 0.608	(sec) 0cclusion 0.071 0.167 0.221 0.267 0.117 0.158 0.163 0.258 0.171	(sec) Opening time 0.383 0.167 0.163 0.171 0.175 0.192 0.158 0.138 0.217	(sec) Closing time 0.217 0.217 0.213 0.221 0.275 0.254 0.429 0.154 0.221	(mm/sec) Opening maximal velocity 90.768 148.807 165.362 110.101 128.281 173.556 140.534 170.661 128.575	(mm/sec) Closing maximal velocity 144.345 106.86 119.8 82.813 88.252 119.809 58.203 141.654 130.619	(mm) Opening magnitude 21.503 18.592 19.319 14.907 16.516 21.46 15.228 18.051 20.873	Table 1-3 Movement analysis of mouth opening-closing.   opening-closing.     opening-closing.   Subject B, Wearing the complete mandibular denture without suction     Subject A, Dentulous healthy subject   Name: D1     Name: C   Data closification: From showing	1 2 3 4 5 6 7 8 9	ning-closing time 0.658 0.708 0.746 0.746 0.679 0.679 0.833 0.654 0.771	0cclusion time 0.163 0.208 0.275 0.229 0.379 0.242 0.292 0.292 0.183 0.267	Opening time 0.358 0.213 0.233 0.204 0.175 0.225 0.246 0.225 0.258	Closing time 0.138 0.288 0.238 0.213 0.213 0.213 0.296 0.246 0.246	0pening maximal velocity 34.044 70.102 86.702 62.024 66.09 58.922 78.451 95.445 56.501	Closing maximal velocity 69.934 39.28 62.698 51.45 46.423 60.36 63.741 52.674 68.561	0pening magnitude 6.068 8.503 11.159 8.552 6.987 9.973 10.161 10.059 11.051
1 2 3 4 5 6 7 8 9 10	ning-closing time 0.671 0.55 0.596 0.658 0.567 0.604 0.75 0.55 0.608 0.633	(sec) 0cclusion 0.071 0.167 0.221 0.267 0.117 0.158 0.163 0.258 0.171 0.2	(sec) Opening time 0.383 0.167 0.163 0.171 0.175 0.192 0.158 0.138 0.217 0.183	(sec) Closing time 0.217 0.217 0.213 0.221 0.275 0.254 0.429 0.154 0.221 0.25	(mm/sec) Opening maximal velocity 90.768 148.807 165.362 110.101 128.281 173.556 140.534 170.661 128.575 143.497	(mm/sec) Closing maximal velocity 144.345 106.86 119.8 82.813 88.252 119.809 58.203 141.654 130.619 106.807	(mm) Opening magnitude 21.503 18.592 19.319 14.907 16.516 21.46 15.228 18.051 20.873 18.353	Table 1-3 Movement analysis of mouth opening-closing.   opening-closing.     opening-closing.   Subject B, Wearing the complete mandibular denture without suction     Subject A, Dentulous healthy subject   Name: D1     Name: C   Data closification: From showing	1 2 3 4 5 6 7 8 9 10	ning-closing time 0.658 0.708 0.746 0.746 0.679 0.833 0.654 0.771 0.721	Occlusion time 0.163 0.208 0.275 0.229 0.379 0.242 0.292 0.183 0.267 0.225	Opening time 0.358 0.213 0.233 0.204 0.175 0.225 0.246 0.225 0.246 0.225 0.258 0.275	Closing time 0.138 0.288 0.238 0.213 0.213 0.213 0.296 0.246 0.246 0.221	0pening maximal velocity 34.044 70.102 86.702 62.024 66.09 58.922 78.451 95.445 56.501 63.724	Closing maximal velocity 69.934 39.28 62.698 51.45 46.423 60.36 63.741 52.674 68.561 80.01	0pening magnitude 6.068 8.503 11.159 8.552 6.987 9.973 10.161 10.059 11.051 11.587
1 2 3 4 5 6 7 8 9 10 11	ning-closing time 0.671 0.55 0.596 0.658 0.658 0.604 0.75 0.55 0.608 0.633 0.6	(sec) 0cclusion time 0.071 0.167 0.221 0.267 0.117 0.158 0.163 0.258 0.171 0.2 0.171	(sec) Opening time 0.383 0.167 0.163 0.171 0.175 0.192 0.158 0.138 0.217 0.183 0.238	(sec) (losing time 0.217 0.213 0.221 0.275 0.254 0.429 0.154 0.221 0.25 0.192	(mm/sec) Opening maximal velocity 90.768 148.807 165.362 110.101 128.281 173.556 140.534 170.661 128.575 143.497 110.435	(mm/sec) Closing maximal velocity 144.345 106.86 119.8 82.813 88.252 119.809 58.203 141.654 130.619 106.807 139.566	(mm) Opening magnitude 21.503 18.592 19.319 14.907 16.516 21.46 15.228 18.051 20.873 18.353 19.756	Table 1-3 Movement analysis of mouth opening-closing.   opening-closing.     opening-closing.   Subject B, Wearing the complete mandibular denture without suction     Subject A, Dentulous healthy subject   Name: D1     Name: C   Data closification: From showing	1 2 3 4 5 6 7 8 9 10 11	ning-closing time 0.658 0.708 0.746 0.746 0.767 0.833 0.654 0.771 0.721 0.721 0.717	Occlusion time 0.163 0.208 0.275 0.229 0.379 0.242 0.292 0.183 0.267 0.225 0.221	Opening time 0.358 0.213 0.233 0.204 0.175 0.225 0.246 0.225 0.246 0.225 0.258 0.275 0.238	Closing time 0.138 0.288 0.238 0.213 0.213 0.296 0.246 0.246 0.221 0.258	0pening maximal velocity 34.044 70.102 86.702 62.024 66.09 58.922 78.451 95.445 56.501 63.724 78.72	Closing maximal velocity 69.934 39.28 62.698 51.45 46.423 60.36 63.741 52.674 68.561 80.01 60.294	0pening magnitude 6.068 8.503 11.159 8.552 6.987 9.973 10.161 10.059 11.051 11.587 12.37
1 2 3 4 5 6 7 8 9 10 11 12	hing-closing time 0.671 0.55 0.596 0.658 0.567 0.604 0.55 0.608 0.633 0.6 0.642	(sec) 0cclusion time 0.071 0.167 0.221 0.267 0.117 0.158 0.163 0.258 0.171 0.2 0.171 0.229	(sec) Opening time 0.383 0.167 0.163 0.171 0.175 0.192 0.158 0.138 0.217 0.183 0.238 0.175	(sec) Closing time 0.217 0.213 0.221 0.275 0.254 0.429 0.154 0.221 0.25 0.192 0.238	(mm/sec) 0pening maximal velocity 90.768 148.807 165.362 110.101 128.281 173.556 140.534 140.534 140.534 140.535 143.497 110.435 146.787	(mm/sec) Closing maximal velocity 144.345 106.86 119.8 82.813 88.252 119.809 58.203 141.654 130.619 106.807 139.566 97.817	(mm) Opening magnitude 21.503 18.592 19.319 14.907 16.516 21.46 15.228 18.051 20.873 18.353 19.756 17.755	Table 1-3 Movement analysis of mouth opening-closing.   opening-closing.     opening-closing.   Subject B, Wearing the complete mandibular denture without suction     Subject A, Dentulous healthy subject   Name: D1     Name: C   Data closification: From showing	1 2 3 4 5 6 7 8 9 10 11 12	ning-closing time 0.658 0.708 0.746 0.746 0.767 0.679 0.833 0.654 0.771 0.721 0.721 0.717 0.738	Occlusion time 0.163 0.208 0.275 0.229 0.379 0.242 0.292 0.183 0.267 0.225 0.221 0.275 0.25 0.225	Opening time 0.358 0.213 0.233 0.204 0.175 0.225 0.246 0.225 0.258 0.275 0.238 0.233	Closing time 0.138 0.288 0.238 0.213 0.213 0.296 0.246 0.246 0.221 0.258 0.229	0pening maximal velocity 34.044 70.102 86.702 62.024 66.09 58.922 78.451 95.445 56.501 63.724 78.72 94.389	Closing maximal velocity 69.934 39.28 62.698 51.45 46.423 60.36 63.741 52.674 68.561 80.01 60.294 56.347	0pening magnitude 6.068 8.503 11.159 8.552 6.987 9.973 10.161 10.059 11.051 11.587 12.37 10.496
1 2 3 4 5 6 7 8 9 10 11 12 13	hing-closing time 0.671 0.55 0.596 0.658 0.567 0.604 0.75 0.608 0.633 0.6 0.642 0.658	(sec) 0cclusion time 0.071 0.167 0.221 0.267 0.117 0.158 0.163 0.258 0.171 0.2 0.171 0.229 0.388	(sec) Opening time 0.383 0.167 0.163 0.171 0.175 0.192 0.158 0.138 0.217 0.183 0.238 0.175 0.108	(sec) Closing time 0.217 0.213 0.221 0.275 0.254 0.429 0.154 0.221 0.25 0.192 0.238 0.163	(mm/sec) 0pening maximal velocity 90.768 148.807 165.362 110.101 128.281 173.556 140.534 140.534 140.534 140.535 143.497 110.435 146.787 132.909	(mm/sec) Closing maximal velocity 144.345 106.86 119.8 82.813 88.252 119.809 58.203 141.654 130.619 106.807 139.566 97.817 91.687	(mm) Opening magnitude 21.503 18.592 19.319 14.907 16.516 21.46 15.228 18.051 20.873 18.353 19.756 17.755 10.491	Table 1-3 Movement analysis of mouth opening-closing.   opening-closing.     opening-closing.   Subject B, Wearing the complete mandibular denture without suction     Subject A, Dentulous healthy subject   Name: D1     Name: C   Data closification: From showing	1 2 3 4 5 6 7 8 9 10 11 12 13	ning-closing time 0.658 0.708 0.746 0.746 0.746 0.767 0.679 0.833 0.654 0.771 0.721 0.717 0.738 0.675 0.733 0.75	Occlusion time 0.163 0.208 0.275 0.229 0.379 0.242 0.292 0.183 0.267 0.225 0.221 0.275 0.225 0.225 0.225 0.333	Opening time 0.358 0.213 0.233 0.204 0.175 0.225 0.246 0.225 0.246 0.225 0.246 0.225 0.246 0.225 0.248 0.275 0.238 0.2 0.238 0.2	Closing time 0.138 0.288 0.313 0.213 0.213 0.296 0.246 0.246 0.246 0.246 0.246 0.246 0.246 0.221 0.258 0.225 0.271 0.204	0pening maximal velocity 34.044 70.102 86.702 62.024 66.09 58.922 78.451 95.445 56.501 63.724 78.72 94.389 98.34 114.62 63.063	Closing maximal velocity 69.934 39.28 62.698 51.45 46.423 60.36 63.741 52.674 68.561 80.01 60.294 56.347 56.377 56.778 72.426 57.897	0pening magnitude 6.068 8.503 11.159 8.552 6.987 9.973 10.161 10.059 11.051 11.587 12.37 10.496 11.908 13.456 10.11
1 2 3 4 5 6 7 8 9 10 11 12 13 14	ning-closing time 0.671 0.55 0.596 0.658 0.567 0.604 0.75 0.55 0.608 0.633 0.6 0.642 0.658 0.546	(sec) 0cclusion time 0.071 0.167 0.221 0.267 0.117 0.158 0.163 0.258 0.171 0.2 0.171 0.229 0.388 0.196	(sec) Opening time 0.383 0.167 0.163 0.171 0.175 0.192 0.158 0.138 0.217 0.183 0.238 0.175 0.108 0.204	(sec) Closing 0.217 0.217 0.213 0.221 0.275 0.254 0.429 0.154 0.221 0.25 0.192 0.238 0.163 0.146	(mm/sec) 0pening maximal velocity 90.768 148.807 165.362 110.101 128.281 173.556 140.534 170.661 128.575 143.497 110.435 146.787 132.909 114.139	(mm/sec) Closing maximal velocity 144.345 106.86 119.8 82.813 88.252 119.809 58.203 141.654 130.619 106.807 139.566 97.817 91.687 122.051	(mm) Opening magnitude 21.503 18.592 19.319 14.907 16.516 21.46 15.228 18.051 20.873 18.353 19.756 17.755 10.491 12.427	Table 1-3 Movement analysis of mouth opening-closing.   opening-closing.     opening-closing.   Subject B, Wearing the complete mandibular denture without suction     Subject A, Dentulous healthy subject   Name: D1     Name: C   Data closification: From showing	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16	ning-closing time 0.658 0.708 0.746 0.746 0.767 0.679 0.833 0.654 0.771 0.721 0.717 0.738 0.675 0.733 0.75 0.675	Occlusion time 0.163 0.208 0.275 0.229 0.379 0.242 0.292 0.183 0.267 0.225 0.221 0.275 0.225 0.225 0.333 0.242	Opening time 0.358 0.213 0.233 0.204 0.175 0.225 0.246 0.225 0.246 0.225 0.246 0.225 0.246 0.225 0.248 0.275 0.238 0.233 0.2 0.238 0.213 0.213	Closing time 0.138 0.288 0.238 0.213 0.213 0.213 0.213 0.246 0.246 0.246 0.246 0.246 0.246 0.221 0.258 0.225 0.271 0.204 0.221	0pening maximal velocity 34.044 70.102 86.702 62.024 66.09 58.922 78.451 95.445 56.501 63.724 78.72 94.389 98.34 114.62 63.063 75.13	Closing maximal velocity 69.934 39.28 62.698 51.45 46.423 60.36 63.741 52.674 68.561 80.01 60.294 56.347 56.778 72.426 57.897 55.448	0pening magnitude 6.068 8.503 11.159 8.552 6.987 9.973 10.161 10.059 11.051 11.587 12.37 10.496 11.908 13.456 10.11 11.22
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	hing-closing time 0.671 0.55 0.596 0.658 0.567 0.604 0.75 0.608 0.633 0.6 0.642 0.658 0.546 0.575	(sec) 0cclusion time 0.071 0.167 0.221 0.267 0.117 0.158 0.163 0.258 0.171 0.2 0.171 0.229 0.388 0.196 0.188	(sec) Opening time 0.383 0.167 0.163 0.171 0.175 0.192 0.158 0.138 0.217 0.183 0.238 0.175 0.108 0.204 0.188	(sec) Closing time 0.217 0.213 0.221 0.275 0.254 0.429 0.154 0.221 0.25 0.192 0.238 0.163 0.146 0.2	(mm/sec) Opening maximal velocity 90.768 148.807 165.362 110.101 128.281 173.556 140.534 170.661 128.575 143.497 110.435 146.787 132.909 114.139 115.041	(mm/sec) Closing maximal velocity 144.345 106.86 119.8 82.813 88.252 119.809 58.203 141.654 130.619 106.807 139.566 97.817 91.687 122.051 96.829	(mm) Opening magnitude 21.503 18.592 19.319 14.907 16.516 21.46 15.228 18.051 20.873 18.353 19.756 17.755 10.491 12.427 16.08	Table 1-3 Movement analysis of mouth opening-closing.   opening-closing.     opening-closing.   Subject B, Wearing the complete mandibular denture without suction     Subject A, Dentulous healthy subject   Name: D1     Name: C   Data closification: From showing	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17	ning-closing time 0.658 0.708 0.746 0.767 0.679 0.833 0.654 0.771 0.721 0.717 0.738 0.675 0.733 0.75 0.675 0.654	Occlusion time 0.163 0.208 0.275 0.229 0.379 0.242 0.292 0.183 0.267 0.225 0.221 0.275 0.225 0.225 0.225 0.225 0.333 0.242 0.267	Opening time 0.358 0.213 0.233 0.204 0.175 0.225 0.246 0.225 0.246 0.225 0.246 0.225 0.248 0.275 0.238 0.275 0.238 0.233 0.2 0.238 0.213 0.213 0.213 0.192	Closing time 0.138 0.288 0.238 0.213 0.213 0.213 0.296 0.246 0.246 0.246 0.246 0.246 0.221 0.258 0.229 0.225 0.271 0.204 0.221 0.204 0.221 0.204	0pening maximal velocity 34.044 70.102 86.702 62.024 66.09 58.922 78.451 95.445 56.501 63.724 78.72 94.389 98.34 114.62 63.063 75.13 98.708	Closing maximal velocity 69.934 39.28 62.698 51.45 46.423 60.36 63.741 52.674 68.561 80.01 60.294 56.347 56.778 72.426 57.897 55.448 86.091	0pening magnitude 6.068 8.503 11.159 8.552 6.987 9.973 10.161 10.059 11.051 11.587 12.37 10.496 11.908 13.456 10.11 11.22 12.016
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16	hing-closing time 0.671 0.55 0.596 0.658 0.567 0.604 0.655 0.608 0.633 0.6 0.642 0.658 0.546 0.546 0.575 0.679	(sec) 0cclusion time 0.071 0.167 0.221 0.267 0.117 0.158 0.163 0.258 0.171 0.229 0.388 0.196 0.188 0.258	(sec) Opening time 0.383 0.167 0.163 0.171 0.175 0.192 0.158 0.138 0.217 0.183 0.217 0.183 0.238 0.175 0.108 0.204 0.188 0.188	(sec) Closing time 0.217 0.213 0.221 0.275 0.254 0.429 0.154 0.221 0.255 0.192 0.238 0.163 0.146 0.2 0.233	(mm/sec) Opening maximal velocity 90.768 148.807 165.362 110.101 128.281 173.556 140.534 170.661 128.575 143.497 110.435 146.787 132.909 114.139 115.041 122.06	(mm/sec) Closing maximal velocity 144.345 106.86 119.8 82.813 88.252 119.809 58.203 141.654 130.619 106.807 139.566 97.817 91.687 122.051 96.829 96.708	(mm) Opening magnitude 21.503 18.592 19.319 14.907 16.516 21.46 15.228 18.051 20.873 18.353 19.755 10.491 12.427 16.08 14.477	Table 1-3 Movement analysis of mouth opening-closing.   opening-closing.     opening-closing.   Subject B, Wearing the complete mandibular denture without suction     Subject A, Dentulous healthy subject   Name: D1     Name: C   Data closification: From showing	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18	ning-closing time 0.658 0.708 0.746 0.767 0.679 0.833 0.654 0.771 0.721 0.717 0.738 0.675 0.733 0.75 0.675 0.654 0.733	Occlusion time 0.163 0.208 0.275 0.229 0.379 0.242 0.292 0.183 0.267 0.225 0.225 0.225 0.225 0.225 0.225 0.225 0.225 0.225 0.225 0.233 0.242 0.267 0.275	Opening time 0.358 0.213 0.233 0.204 0.175 0.225 0.246 0.225 0.246 0.225 0.258 0.275 0.238 0.233 0.233 0.2 0.238 0.213 0.213 0.213 0.225	Closing time 0.138 0.288 0.238 0.213 0.213 0.213 0.296 0.246 0.246 0.246 0.246 0.221 0.258 0.229 0.225 0.225 0.271 0.204 0.221 0.204 0.221 0.204 0.221	0pening maximal velocity 34.044 70.102 86.702 62.024 66.09 58.922 78.451 95.445 56.501 63.724 78.72 94.389 98.34 114.62 63.063 75.13 98.708 84.255	Closing maximal velocity 69.934 39.28 62.698 51.45 46.423 60.36 63.741 52.674 68.561 80.01 60.294 56.347 56.778 72.426 57.897 55.448 86.091 63.672	Opening magnitude       6.068       8.503       11.159       8.552       6.987       9.973       10.161       10.059       11.51       11.587       12.37       10.496       13.456       10.11       11.22       12.016       13.094
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17	hing-closing time 0.671 0.55 0.596 0.658 0.567 0.604 0.655 0.608 0.642 0.658 0.546 0.575 0.679 0.65	(sec) 0cclusion time 0.071 0.167 0.221 0.267 0.117 0.158 0.163 0.258 0.171 0.229 0.388 0.196 0.188 0.258 0.325	(sec) Opening time 0.383 0.167 0.163 0.171 0.175 0.192 0.158 0.138 0.217 0.183 0.217 0.183 0.238 0.175 0.108 0.204 0.188 0.204 0.188 0.125	(sec) Closing time 0.217 0.213 0.221 0.275 0.254 0.429 0.154 0.221 0.25 0.192 0.238 0.163 0.146 0.2 0.233 0.23 0.233 0.2	(mm/sec) Opening maximal velocity 90.768 148.807 165.362 110.101 128.281 173.556 140.534 170.661 128.575 143.497 110.435 146.787 132.909 114.139 115.041 122.06 137.271	(mm/sec) Closing maximal velocity 144.345 106.86 119.8 82.813 88.252 119.809 58.203 141.654 130.619 106.807 139.566 97.817 91.687 122.051 96.829 96.708 76.513	(mm) Opening magnitude 21.503 18.592 19.319 14.907 16.516 21.46 15.228 18.051 20.873 18.353 19.755 10.491 12.427 16.08 14.477 13.471	Table 1-3 Movement analysis of mouth opening-closing.   opening-closing.     opening-closing.   Subject B, Wearing the complete mandibular denture without suction     Subject A, Dentulous healthy subject   Name: D1     Name: C   Data closification: From showing	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19	ning-closing time 0.658 0.708 0.746 0.746 0.767 0.679 0.833 0.654 0.771 0.721 0.717 0.738 0.675 0.733 0.75 0.675 0.675 0.654 0.733 0.633	Occlusion time       0.163       0.208       0.275       0.229       0.379       0.242       0.292       0.183       0.267       0.225       0.221       0.275       0.255       0.225       0.333       0.242       0.267       0.275       0.233	Opening time 0.358 0.213 0.233 0.204 0.175 0.225 0.246 0.225 0.246 0.225 0.246 0.225 0.238 0.233 0.2 0.238 0.233 0.2 0.238 0.213 0.213 0.213 0.225 0.183	Closing time 0.138 0.288 0.238 0.213 0.213 0.213 0.213 0.296 0.246 0.246 0.246 0.246 0.221 0.258 0.229 0.225 0.271 0.204 0.221 0.204 0.221 0.204 0.221 0.204 0.221 0.204 0.221 0.204	0pening maximal velocity 34.044 70.102 86.702 62.024 66.09 58.922 78.451 95.445 56.501 63.724 78.72 94.389 98.34 114.62 63.063 75.13 98.708 84.255 112.942	Closing maximal velocity 69.934 39.28 62.698 51.45 46.423 60.36 63.741 52.674 68.561 80.01 60.294 56.347 56.778 72.426 57.897 55.448 86.091 63.672 68.418	0pening magnitude 6.068 8.503 11.159 8.552 6.987 9.973 10.161 10.059 11.051 11.587 12.37 10.496 11.908 13.456 10.11 11.22 12.016 13.094 12.456
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18	ning-closing time 0.671 0.55 0.596 0.658 0.567 0.604 0.655 0.608 0.633 0.6 0.642 0.658 0.642 0.658 0.575 0.679 0.65 0.629	(sec) 0cclusion time 0.071 0.167 0.221 0.267 0.117 0.158 0.163 0.258 0.171 0.229 0.388 0.196 0.188 0.258 0.325 0.246	(sec) Opening time 0.383 0.167 0.163 0.171 0.175 0.192 0.158 0.138 0.217 0.183 0.238 0.175 0.108 0.204 0.188 0.125 0.196	(sec) Closing time 0.217 0.213 0.221 0.275 0.254 0.429 0.154 0.221 0.25 0.192 0.238 0.163 0.146 0.2 0.233 0.223 0.233 0.223 0.233 0.223 0.233 0.223 0.233 0.223 0.233 0.223 0.233 0.223 0.233 0.223 0.233 0.223 0.233 0.223 0.233 0.223 0.234 0.255 0.254 0.255 0.254 0.255 0.254 0.255 0.254 0.255 0.254 0.255 0.254 0.255 0.254 0.255 0.254 0.255 0.254 0.255 0.254 0.255 0.254 0.255 0.254 0.255 0.254 0.255 0.254 0.255 0.254 0.255 0.254 0.255 0.254 0.253 0.253 0.258 0.238 0.163 0.233 0.223 0.253 0.253 0.254 0.258 0.258 0.258 0.258 0.258 0.258 0.258 0.258 0.258 0.258 0.258 0.258 0.163 0.254 0.255 0.25	(mm/sec) Opening maximal velocity 90.768 148.807 165.362 110.101 128.281 173.556 140.534 170.661 128.575 143.497 110.435 146.787 132.909 114.139 115.041 122.06 137.271 137.439	(mm/sec) Closing maximal velocity 144.345 106.86 119.8 82.813 88.252 119.809 58.203 141.654 130.619 106.807 139.566 97.817 91.687 122.051 96.829 96.708 76.513 107.198	(mm) Opening magnitude 21.503 18.592 19.319 14.907 16.516 21.46 15.228 18.051 20.873 18.353 19.755 10.491 12.427 16.08 14.477 13.471 15.696	Table 1-3 Movement analysis of mouth opening-closing.   opening-closing.     opening-closing.   Subject B, Wearing the complete mandibular denture without suction     Subject A, Dentulous healthy subject   Name: D1     Name: C   Data closification: From showing	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20	ning-closing time 0.658 0.708 0.746 0.746 0.767 0.679 0.833 0.654 0.771 0.721 0.717 0.738 0.675 0.733 0.675 0.654 0.733 0.654 0.733 0.654 0.733 0.654	Occlusion time       0.163       0.208       0.275       0.229       0.379       0.242       0.292       0.183       0.267       0.225       0.225       0.225       0.233       0.242       0.255	Opening time 0.358 0.213 0.233 0.204 0.175 0.225 0.246 0.225 0.246 0.225 0.246 0.225 0.238 0.275 0.238 0.233 0.2 0.238 0.213 0.213 0.213 0.192 0.225 0.183 0.175	Closing time 0.138 0.288 0.238 0.213 0.213 0.213 0.213 0.296 0.246 0.246 0.246 0.221 0.258 0.225 0.271 0.204 0.225 0.271 0.204 0.221 0.204 0.221 0.204 0.221 0.204 0.221 0.204 0.221 0.204 0.221 0.204 0.221 0.225	0pening maximal velocity 34.044 70.102 86.702 62.024 66.09 58.922 78.451 95.445 56.501 63.724 78.72 94.389 98.34 114.62 63.063 75.13 98.708 84.255 112.942 125.283	Closing maximal velocity 69.934 39.28 62.698 51.45 46.423 60.36 63.741 52.674 68.561 80.01 60.294 56.347 56.778 72.426 57.897 55.448 86.091 63.672 68.418 64.174	0pening magnitude 6.068 8.503 11.159 8.552 6.987 9.973 10.161 10.059 11.051 11.587 12.37 10.496 11.908 13.456 10.11 11.22 12.016 13.094 12.456 12.991
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19	ning-closing time 0.671 0.55 0.596 0.658 0.658 0.664 0.75 0.608 0.633 0.6 0.642 0.658 0.546 0.575 0.679 0.65 0.629 0.479	(sec) 0cclusion time 0.071 0.167 0.221 0.267 0.117 0.158 0.163 0.258 0.171 0.229 0.388 0.196 0.188 0.258 0.325 0.325 0.325 0.246 0.175	(sec) Opening time 0.383 0.167 0.163 0.171 0.175 0.192 0.158 0.217 0.183 0.238 0.175 0.108 0.204 0.188 0.204 0.188 0.125 0.196 0.158	(sec) (losing ime 0.217 0.217 0.213 0.221 0.275 0.254 0.429 0.154 0.221 0.25 0.192 0.238 0.163 0.146 0.2 0.233 0.2 0.288 0.146	(mm/sec) 0pening maximal velocity 90.768 148.807 165.362 110.101 128.281 173.556 140.534 170.661 128.575 143.497 110.435 146.787 132.909 114.139 115.041 122.06 137.271 137.439 69.063	(mm/sec) Closing maximal velocity 144.345 106.86 119.8 82.813 88.252 119.809 58.203 141.654 130.619 106.807 139.566 97.817 91.687 122.051 96.829 96.708 76.513 107.198 70.208	(mm) Opening magnitude 21.503 18.592 19.319 14.907 16.516 21.46 15.228 18.051 20.873 18.353 19.756 17.755 10.491 12.427 16.08 14.477 13.471 15.696 9.652	Table 1-3 Movement analysis of mouth opening-closing.   opening-closing.     opening-closing.   Subject B, Wearing the complete mandibular denture without suction     Subject A, Dentulous healthy subject   Name: D1     Name: C   Data closification: From showing	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19	ning-closing time 0.658 0.708 0.746 0.746 0.770 0.679 0.833 0.654 0.771 0.721 0.717 0.738 0.675 0.733 0.675 0.654 0.733 0.654 0.733 0.654 0.733 0.654 0.733 0.654 0.733 0.654 0.733 0.654	Occlusion time       0.163       0.208       0.275       0.229       0.379       0.242       0.292       0.183       0.267       0.225       0.221       0.275       0.225       0.333       0.242       0.267       0.275       0.233       0.255       0.233       0.25	Opening time 0.358 0.213 0.233 0.204 0.175 0.225 0.246 0.225 0.246 0.225 0.258 0.275 0.238 0.233 0.2 0.238 0.213 0.213 0.213 0.213 0.225 0.183 0.175 0.219	Closing time 0.138 0.288 0.238 0.213 0.213 0.213 0.296 0.246 0.246 0.246 0.246 0.246 0.221 0.258 0.225 0.271 0.204 0.225 0.271 0.204 0.233 0.217 0.25 0.241	0pening maximal velocity 34.044 70.102 86.702 62.024 66.09 58.922 78.451 95.445 56.501 63.724 78.72 94.389 98.34 114.62 63.063 75.13 98.708 84.255 112.942 125.283 83.337	Closing maximal velocity 69.934 39.28 62.698 51.45 46.423 60.36 63.741 52.674 68.561 80.01 60.294 56.347 56.778 72.426 57.897 55.448 86.091 63.672 68.418 64.174 61.407	0pening magnitude 6.068 8.503 11.159 8.552 6.987 9.973 10.161 10.059 11.051 11.587 12.37 10.496 11.908 13.456 10.11 11.22 12.016 13.094 12.456 12.991 10.955
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20	aing-closing time 0.671 0.55 0.596 0.658 0.567 0.604 0.655 0.608 0.633 0.6 0.642 0.658 0.546 0.575 0.679 0.65 0.629 0.479 1.025	(sec) 0cclusion time 0.071 0.167 0.221 0.267 0.117 0.158 0.163 0.258 0.171 0.229 0.388 0.196 0.188 0.258 0.325 0.246 0.175 0.742	(sec) Opening time 0.383 0.167 0.163 0.171 0.175 0.192 0.158 0.175 0.183 0.238 0.175 0.108 0.204 0.188 0.125 0.196 0.158 0.117	(sec) (losing ime 0.217 0.217 0.213 0.221 0.255 0.254 0.429 0.154 0.221 0.25 0.192 0.238 0.163 0.146 0.2 0.233 0.2 0.233 0.2 0.233 0.2 0.233 0.2 0.233 0.2 0.233 0.2 0.233 0.2 0.233 0.2 0.233 0.2 0.233 0.2 0.233 0.2 0.233 0.2 0.233 0.2 0.254 0.255 0.54 0.54 0.54 0.255 0.54 0.255 0.254 0.255 0.254 0.255 0.255 0.254 0.221 0.255 0.254 0.221 0.255 0.254 0.221 0.255 0.254 0.221 0.255 0.254 0.221 0.255 0.254 0.221 0.255 0.223 0.238 0.163 0.146 0.2 0.233 0.2 0.233 0.2 0.233 0.2 0.253 0.2 0.253 0.2 0.253 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2	(mm/sec) Opening maximal velocity 90.768 148.807 165.362 110.101 128.281 173.556 140.534 170.661 128.575 143.497 110.435 146.787 132.909 114.139 115.041 122.06 137.271 137.439 69.063 125.816	(mm/sec) Closing maximal velocity 144.345 106.86 119.8 82.813 88.252 119.809 58.203 141.654 130.619 106.807 139.566 97.817 91.687 122.051 96.829 96.708 76.513 107.198 70.208 85.43	(mm) Opening magnitude 21.503 18.592 19.319 14.907 16.516 21.46 15.228 18.051 20.873 18.353 19.756 17.755 10.491 12.427 16.08 14.477 13.471 15.696 9.652 11.577	Table 1-3 Movement analysis of mouth opening-closing.   opening-closing.     opening-closing.   Subject B, Wearing the complete mandibular denture without suction     Subject A, Dentulous healthy subject   Name: D1     Name: C   Data closification: From showing	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20	ning-closing time 0.658 0.708 0.746 0.746 0.767 0.679 0.833 0.654 0.771 0.721 0.717 0.738 0.675 0.733 0.675 0.654 0.733 0.654 0.733 0.654 0.733 0.654	Occlusion time       0.163       0.208       0.275       0.229       0.379       0.242       0.292       0.183       0.267       0.225       0.225       0.225       0.233       0.242       0.255	Opening time 0.358 0.213 0.233 0.204 0.175 0.225 0.246 0.225 0.246 0.225 0.246 0.225 0.238 0.275 0.238 0.233 0.2 0.238 0.213 0.213 0.213 0.192 0.225 0.183 0.175	Closing time 0.138 0.288 0.238 0.213 0.213 0.213 0.213 0.296 0.246 0.246 0.246 0.221 0.258 0.225 0.271 0.204 0.225 0.271 0.204 0.221 0.204 0.221 0.204 0.221 0.204 0.221 0.204 0.221 0.204 0.221 0.204 0.221 0.225	0pening maximal velocity 34.044 70.102 86.702 62.024 66.09 58.922 78.451 95.445 56.501 63.724 78.72 94.389 98.34 114.62 63.063 75.13 98.708 84.255 112.942 125.283	Closing maximal velocity 69.934 39.28 62.698 51.45 46.423 60.36 63.741 52.674 68.561 80.01 60.294 56.347 56.778 72.426 57.897 55.448 86.091 63.672 68.418 64.174	0pening magnitude 6.068 8.503 11.159 8.552 6.987 9.973 10.161 10.059 11.051 11.587 12.37 10.496 11.908 13.456 10.11 11.22 12.016 13.094 12.456 12.991
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19	ning-closing time 0.671 0.55 0.596 0.658 0.567 0.604 0.75 0.55 0.608 0.633 0.6 0.642 0.658 0.546 0.575 0.679 0.65 0.629 0.479	(sec) 0cclusion time 0.071 0.167 0.221 0.267 0.117 0.158 0.163 0.258 0.171 0.258 0.171 0.229 0.388 0.196 0.188 0.258 0.325 0.325 0.325 0.246 0.175	(sec) Opening time 0.383 0.167 0.163 0.171 0.175 0.192 0.158 0.217 0.183 0.238 0.175 0.108 0.204 0.188 0.204 0.188 0.125 0.196 0.158	(sec) (losing ime 0.217 0.217 0.213 0.221 0.275 0.254 0.429 0.154 0.221 0.25 0.192 0.238 0.163 0.146 0.2 0.233 0.2 0.188 0.146	(mm/sec) 0pening maximal velocity 90.768 148.807 165.362 110.101 128.281 173.556 140.534 170.661 128.575 143.497 110.435 146.787 132.909 114.139 115.041 122.06 137.271 137.439 69.063	(mm/sec) Closing maximal velocity 144.345 106.86 119.8 82.813 88.252 119.809 58.203 141.654 130.619 106.807 139.566 97.817 91.687 122.051 96.829 96.708 76.513 107.198 70.208	(mm) Opening magnitude 21.503 18.592 19.319 14.907 16.516 21.46 15.228 18.051 20.873 18.353 19.756 17.755 10.491 12.427 16.08 14.477 13.471 15.696 9.652	Table 1-3 Movement analysis of mouth opening-closing.   opening-closing.     opening-closing.   Subject B, Wearing the complete mandibular denture without suction     Subject A, Dentulous healthy subject   Name: D1     Name: C   Data closification: From showing	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20	ning-closing time 0.658 0.708 0.746 0.746 0.770 0.679 0.833 0.654 0.771 0.721 0.717 0.738 0.675 0.733 0.675 0.654 0.733 0.654 0.733 0.654 0.733 0.654 0.733 0.654 0.733 0.654 0.733 0.654	Occlusion time       0.163       0.208       0.275       0.229       0.379       0.242       0.292       0.183       0.267       0.225       0.221       0.275       0.225       0.333       0.242       0.267       0.275       0.233       0.255       0.233       0.25	Opening time 0.358 0.213 0.233 0.204 0.175 0.225 0.246 0.225 0.246 0.225 0.258 0.275 0.238 0.233 0.2 0.238 0.213 0.213 0.213 0.213 0.225 0.183 0.175 0.219	Closing time 0.138 0.288 0.238 0.213 0.213 0.213 0.296 0.246 0.246 0.246 0.246 0.246 0.221 0.258 0.225 0.271 0.204 0.225 0.271 0.204 0.233 0.217 0.25 0.241	0pening maximal velocity 34.044 70.102 86.702 62.024 66.09 58.922 78.451 95.445 56.501 63.724 78.72 94.389 98.34 114.62 63.063 75.13 98.708 84.255 112.942 125.283 83.337	Closing maximal velocity 69.934 39.28 62.698 51.45 46.423 60.36 63.741 52.674 68.561 80.01 60.294 56.347 56.778 72.426 57.897 55.448 86.091 63.672 68.418 64.174 61.407	Opening magnitude 6.068 8.503 11.159 8.552 6.987 9.973 10.161 10.059 11.051 11.587 12.37 10.496 11.908 13.456 10.11 11.22 12.016 13.094 12.456 12.991 10.955

#### 3. Mandibular jaw movement velocity

Higher velocity values exhibited in all cases of chewing with D2 in comparison with D1.

1) Maximal velocity at mouth opening

2)

	Right-lateral chewing	D2 <c<d1< td=""></c<d1<>
	Left-lateral chewing	C <d2<d1< td=""></d2<d1<>
	Free chewing	D2 <c<d1< td=""></c<d1<>
Maximal velocity at mou	th closing	
	Right-lateral chewing	D2 <c<d1< td=""></c<d1<>
	Left-lateral chewing	C <d2<d1< td=""></d2<d1<>
	Free chewing	D2 <c<d1< td=""></c<d1<>

4. Masticatory rhythm and masticatory pattern

Higher stability behavior exhibited in case of masticatory rhythm with D2 in comparison with D1.

And in case of masticatory patterns, both D1 and D2 showed a grinding type of masticatory pattern, and cases of D1 indicated a pattern of slightly chopper type. C showed a chopping type.

## **IV. Discussion**

- 1. Experimental methodology
- 1) Tested subjects

Since variety of ages of subjects and experiences of denture wearing were reported to have an influence on their masticatory function<sup>14</sup>, measurements in this study were made to use both the complete mandibular denture with suction and without suction in one same subject.

#### 2) Tested food material

Fish sausage is known for its uniform composition with less property change and is understood valid for comparative study of masticatory rhythm and pattern.

3) Data analysis of Gnatho-Hexagraph II, mandibular jaw movement measuring device

As far as the edentulous subject B is concerned, analysis data

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have been combined, in a strict sense, both with the mandibular jaw movement and with the complete mandibular denture mobility under the mucosal compression of denture bearing area of the residual ridge. So it needs to be remembered that measurement data is substantially different from that of precise mandibular jaw movement of the subject A.

But it may be understood that most likely results will be obtained.

#### 2. Experimental results

In this case of maxillo-mandibular edentulous patient, nearly all measurement items were found varied throughout wearing the complete mandibular denture without suction and the

Comparisons of Masticator		

Stroke								
	Opening-closing time	Occlusion time	Opening time	Closing time	Opening maximal velocity	Closing maximal velocity	Opening magnitude	Table 1-7 Movement analysis of mouth
1	1.592	0.563	0.738	0.292	90.876	90.223	16.804	opening-closing.
2	0.742	0.338	0.2	0.204	106.216	101.446	14.694	Subject B, Wearing the complete mandibular
3	0.808	0.363	0.213	0.233	128.9	106.975	18.055	denture with suction
4	0.758	0.313	0.221	0.225	114.544	104.103	14.864	Name: D2
5	0.783	0.308	0.238	0.238	111.114	111.112	18.134	Data classification: Right chewing
6	0.717	0.254	0.229	0.233	118.332	109.917	16.818	Data classification. hight chewing
7	0.671	0.229	0.204	0.238	144.187	127.006	19.233	
8	0.842	0.329	0.267	0.246	140.237	112.638	18.129	
9	0.692	0.238	0.217	0.238	149.828	98.102	17.311	
10	0.658	0.246	0.204	0.208	113.383	108.752	16.43	
Ave (2-10		0.291	0.221	0.229	125.193	108.895	17.074	
-	(sec)	(sec)	(sec)	(sec)	(mm/sec)	(mm/sec)	(mm)	
								Table 1-8 Movement analysis of mouth
Stroke	Opening-closing time	Occlusion time	Opening time	Closing time	Opening maximal velocity	Closing maximal velocity	Opening magnitude	opening-closing.
1	0.829	0.213	0.379	0.238	57.296	101.498	15.347	
2	0.792	0.363	0.233	0.196	93.479	98.904	14.858	Subject B, Wearing the complete mandibular
3	0.8	0.317	0.229	0.254	107.404	101.367	17.619	denture with suction
4	0.696	0.258	0.221	0.217	112.942	95.992	13.963	Name: D2
5	0.679	0.213	0.225	0.242	140.387	116.107	16.261	Data classification: Left chewing
6	0.75	0.254	0.267	0.229	110.355	118.845	18.619	Data classification. Ecre chewing
7	0.654	0.208	0.221	0.225	90.888	90.834	12.788	
8	0.75	0.283	0.221	0.246	114.654	97.513	14.93	
9	0.729	0.275	0.213	0.242	86.17	83.382	14.324	
10	0.692	0.279	0.183	0.229	126.743	93.98	15.469	
Ave (2-10		0.272	0.224	0.231	109.225			
			0.227	0.231	109.225	99.058	15.420	
	(sec)	(sec)	(sec)	(sec)	(mm/sec)	99.658 (mm/sec)	15.426 (mm)	
	(sec)	(sec)	(sec)	(sec)	(mm/sec)	(mm/sec)	(mm)	Table 1-9 Movement analysis of mouth
	(sec)	(sec) Occlusion	(sec)		(mm/sec) Opening maximal	(mm/sec)	(mm) Opening	Table 1-9 Movement analysis of mouth
Stroke	(sec) Opening-closing time	(sec) Occlusion time	(sec) Opening time	(sec) Closing time	(mm/sec) Opening maximal velocity	(mm/sec) Closing maximal velocity	(mm) Opening magnitude	opening-closing.
Stroke 1	(sec) Opening-closing time 0.888	(sec) Occlusion time 0.279	(sec) Opening time 0.413	(sec) Closing time 0.196	(mm/sec) Opening maximal velocity 72.675	(mm/sec) Closing maximal velocity 152.883	(mm) Opening magnitude 18.707	-
Stroke 1 2	(sec) Opening-closing time 0.888 0.646	(sec) 0cclusion time 0.279 0.267	(sec) Opening time 0.413 0.188	(sec) Closing time 0.196 0.192	(mm/sec) Opening maximal velocity 72.675 165.634	(mm/sec) Closing maximal velocity 152.883 129.317	(mm) Opening magnitude 18.707 16.746	opening-closing.
Stroke 1 2 3	(sec) Opening-closing time 0.888 0.646 0.679	(sec) 0cclusion time 0.279 0.267 0.279	(sec) Opening time 0.413 0.188 0.183	(sec) (losing time 0.196 0.192 0.217	(mm/sec) Opening maximal velocity 72.675 165.634 154.145	(mm/sec) Closing maximal velocity 152.883 129.317 106.441	(mm) Opening magnitude 18.707	opening-closing. Subject B, Wearing the complete mandibular
Stroke 1 2 3 4	(sec) Opening-closing time 0.888 0.646 0.679 0.792	(sec) 0cclusion time 0.279 0.267 0.279 0.275	(sec) Opening time 0.413 0.188 0.183 0.242	(sec) (losing time 0.196 0.192 0.217 0.275	(mm/sec) Opening maximal velocity 72.675 165.634 154.145 147.801	(mm/sec) Closing maximal velocity 152.883 129.317 106.441 110.131	(mm) Opening magnitude 18.707 16.746 16.466 19.6	opening-closing. Subject B, Wearing the complete mandibular denture with suction Name: D2
Stroke 1 2 3 4 5	(sec) Opening-closing time 0.888 0.646 0.679 0.792 0.658	(sec) 0cclusion time 0.279 0.267 0.279 0.275 0.238	(sec) 0pening time 0.413 0.188 0.183 0.242 0.196	(sec) Closing time 0.196 0.192 0.217 0.275 0.225	(mm/sec) Opening maximal velocity 72.675 165.634 154.145 147.801 114.059	(mm/sec) Closing maximal velocity 152.883 129.317 106.441 110.131 127.833	(mm) 0pening magnitude 18.707 16.746 16.466 19.6 18.025	opening-closing. Subject B, Wearing the complete mandibular denture with suction
Stroke 1 2 3 4 5 6	(sec) 0pening-closing time 0.888 0.646 0.679 0.792 0.658 0.7	(sec) 0cclusion time 0.279 0.267 0.279 0.275 0.238 0.258	(sec) Opening time 0.413 0.188 0.183 0.242 0.196 0.204	(sec) Closing time 0.196 0.192 0.217 0.275 0.225 0.238	(mm/sec) Opening maximal velocity 72.675 165.634 154.145 147.801 114.059 160.339	(mm/sec) Closing maximal velocity 152.883 129.317 106.441 110.131 127.833 112.728	(mm) 0pening magnitude 18.707 16.746 16.466 19.6 18.025 17.284	opening-closing. Subject B, Wearing the complete mandibular denture with suction Name: D2
Stroke 1 2 3 4 5 6 7	(sec) 0pening-closing time 0.888 0.646 0.679 0.792 0.658 0.7 0.667	(sec) 0cclusion time 0.279 0.267 0.279 0.275 0.238 0.258 0.283	(sec) 0pening time 0.413 0.188 0.183 0.242 0.196 0.204 0.167	(sec) Closing time 0.196 0.192 0.217 0.275 0.225 0.238 0.217	(mm/sec) Opening maximal velocity 72.675 165.634 154.145 147.801 114.059 160.339 124.445	(mm/sec) Closing maximal velocity 152.883 129.317 106.441 110.131 127.833 112.728 105.257	(mm) 0pening magnitude 18.707 16.746 16.466 19.6 18.025 17.284 16.527	opening-closing. Subject B, Wearing the complete mandibular denture with suction Name: D2
Stroke 1 2 3 4 5 6 7 8	(sec) 0pening-closing time 0.888 0.646 0.679 0.658 0.7 0.667 0.65	(sec) 0cclusion time 0.279 0.267 0.275 0.238 0.258 0.283 0.229	(sec) 0pening time 0.413 0.188 0.183 0.242 0.196 0.204 0.167 0.192	(sec) Closing time 0.196 0.192 0.217 0.275 0.225 0.238 0.217 0.229	(mm/sec) Opening maximal velocity 72.675 165.634 154.145 147.801 114.059 160.339 124.445 102.886	(mm/sec) Closing maximal velocity 152.883 129.317 106.441 110.131 127.833 112.728 105.257 81.066	(mm) 0pening magnitude 18.707 16.746 16.466 19.6 18.025 17.284 16.527 15.427	opening-closing. Subject B, Wearing the complete mandibular denture with suction Name: D2
Stroke 1 2 3 4 5 6 7 8 9	(sec) 0pening-closing time 0.888 0.646 0.679 0.658 0.7 0.667 0.65 0.608	(sec) 0cclusion time 0.279 0.267 0.279 0.275 0.238 0.258 0.283 0.229 0.263	(sec) 0pening time 0.413 0.188 0.183 0.242 0.196 0.204 0.167 0.192 0.129	(sec) Closing time 0.196 0.217 0.275 0.225 0.238 0.217 0.229 0.217	(mm/sec) Opening maximal velocity 72.675 165.634 154.145 147.801 114.059 160.339 124.445 102.886 131.867	(mm/sec) Closing maximal velocity 152.883 129.317 106.441 110.131 127.833 112.728 105.257 81.066 81.043	(mm) 0pening magnitude 18.707 16.746 16.466 19.6 18.025 17.284 16.527 15.427 12.747	opening-closing. Subject B, Wearing the complete mandibular denture with suction Name: D2
Stroke 1 2 3 4 5 6 7 8 9 10	(sec) 0pening-closing time 0.888 0.646 0.679 0.658 0.7 0.667 0.667 0.65 0.608 0.738	(sec) 0cclusion time 0.279 0.267 0.275 0.275 0.238 0.258 0.283 0.229 0.263 0.263 0.313	(sec) 0pening time 0.413 0.188 0.183 0.242 0.196 0.204 0.167 0.192 0.129 0.183	(sec) (losing time 0.196 0.192 0.217 0.225 0.238 0.217 0.229 0.217 0.229	(mm/sec) Opening maximal velocity 72.675 165.634 154.145 147.801 114.059 160.339 124.445 102.886 131.867 138.837	(mm/sec) Closing maximal velocity 152.883 129.317 106.441 110.131 127.833 112.728 105.257 81.066 81.043 96.577	(mm) 0pening magnitude 18.707 16.746 16.466 19.6 18.025 17.284 16.527 15.427 12.747 16.591	opening-closing. Subject B, Wearing the complete mandibular denture with suction Name: D2
Stroke 1 2 3 4 5 6 7 8 9 10 11	(sec) 0pening-closing time 0.888 0.646 0.679 0.679 0.658 0.7 0.667 0.667 0.65 0.608 0.738 0.6	(sec) 0cclusion time 0.279 0.267 0.275 0.238 0.258 0.283 0.229 0.263 0.229 0.263 0.313 0.217	(sec) 0pening time 0.413 0.188 0.183 0.242 0.196 0.204 0.167 0.192 0.129 0.129 0.183 0.204	(sec) (losing time 0.196 0.192 0.217 0.275 0.238 0.217 0.229 0.217 0.242 0.179	(mm/sec) Opening maximal velocity 72.675 165.634 154.145 147.801 114.059 160.339 124.445 102.886 131.867 138.837 178.304	(mm/sec) Closing maximal velocity 152.883 129.317 106.441 110.131 127.883 112.728 105.257 81.066 81.043 96.577 139.424	(mm) 0pening magnitude 18.707 16.746 16.466 19.6 18.025 17.284 16.527 15.427 15.427 12.747 16.591 18.79	opening-closing. Subject B, Wearing the complete mandibular denture with suction Name: D2
Stroke 1 2 3 4 5 6 7 8 9 10 11 12	(sec) 0pening-closing time 0.888 0.646 0.679 0.792 0.658 0.7 0.667 0.667 0.65 0.608 0.738 0.6 0.788	(sec) 0cclusion time 0.279 0.267 0.275 0.238 0.258 0.283 0.229 0.263 0.313 0.217 0.454	(sec) Opening time 0.413 0.188 0.183 0.242 0.196 0.204 0.167 0.192 0.129 0.183 0.204 0.15	(sec) (losing time 0.196 0.192 0.217 0.275 0.238 0.217 0.229 0.217 0.242 0.179 0.183	(mm/sec) Opening maximal velocity 72.675 165.634 154.145 147.801 114.059 160.339 124.445 102.886 131.867 138.837 178.304 171.331	(mm/sec) Closing maximal velocity 152.883 129.317 106.441 110.131 127.833 112.728 105.257 81.066 81.043 96.577 139.424 140.439	(mm) 0pening magnitude 18.707 16.746 16.466 19.6 18.025 17.284 16.527 15.427 12.747 16.591 18.79 17.584	opening-closing. Subject B, Wearing the complete mandibular denture with suction Name: D2
Stroke 1 2 3 4 5 6 7 8 9 10 11 12 13	(sec) 0pening-closing time 0.888 0.646 0.679 0.792 0.658 0.77 0.667 0.667 0.658 0.738 0.738 0.6 0.788 0.613	(sec) 0cdusion time 0.279 0.267 0.275 0.238 0.258 0.283 0.283 0.229 0.263 0.313 0.217 0.454 0.242	(sec) Opening time 0.413 0.188 0.183 0.242 0.196 0.204 0.167 0.192 0.129 0.183 0.204 0.15 0.183	(sec) Closing time 0.192 0.217 0.225 0.238 0.217 0.229 0.217 0.229 0.217 0.242 0.179 0.242 0.179 0.183 0.188	(mm/sec) Opening maximal velocity 72.675 165.634 154.145 147.801 114.059 160.339 124.445 102.886 131.867 138.837 178.304 171.331 143.831	(mm/sec) Closing maximal velocity 152.883 129.317 106.441 110.131 127.883 112.728 105.257 81.066 81.043 96.577 139.424 140.439 109.683	(mm) 0pening magnitude 18.707 16.746 16.466 19.6 18.025 17.284 16.527 15.427 15.427 16.591 18.79 17.584 16.814	opening-closing. Subject B, Wearing the complete mandibular denture with suction Name: D2
Stroke 1 2 3 4 5 6 7 8 9 10 11 12 13 14	(sec) 0pening-closing time 0.888 0.646 0.679 0.792 0.658 0.77 0.667 0.65 0.608 0.738 0.738 0.6 0.788 0.613 0.625	(sec) Occlusion time 0.279 0.267 0.275 0.238 0.258 0.283 0.229 0.263 0.313 0.217 0.454 0.242 0.271	(sec) Opening time 0.413 0.188 0.183 0.242 0.196 0.204 0.167 0.192 0.129 0.183 0.204 0.15 0.183 0.15	(sec) (losing time 0.196 0.197 0.217 0.225 0.238 0.217 0.229 0.217 0.229 0.217 0.229 0.217 0.219 0.217 0.229 0.217 0.219 0.217 0.229 0.217 0.229 0.217 0.229 0.217	(mm/sec) Opening maximal velocity 72.675 165.634 154.145 147.801 114.059 160.339 124.445 102.886 131.867 138.837 178.304 171.331 143.831 143.596	(mm/sec) Closing maximal velocity 152.883 129.317 106.441 110.131 127.833 112.728 105.257 81.066 81.043 96.577 139.424 140.439 109.683 87.163	(mm) 0pening magnitude 18.707 16.746 16.466 19.6 18.025 17.284 16.527 15.427 12.747 16.591 18.79 17.584	opening-closing. Subject B, Wearing the complete mandibular denture with suction Name: D2
Stroke 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	(sec) 0pening-closing time 0.888 0.646 0.679 0.792 0.658 0.77 0.667 0.665 0.608 0.738 0.6 0.738 0.6 0.738 0.613 0.625 0.663	(sec) 0cclusion time 0.279 0.267 0.275 0.238 0.258 0.283 0.229 0.263 0.313 0.217 0.454 0.242 0.271 0.288	(sec) 0pening time 0.413 0.188 0.183 0.242 0.196 0.204 0.167 0.192 0.129 0.183 0.204 0.15 0.183 0.15 0.167	(sec) (losing time 0.196 0.217 0.225 0.238 0.217 0.229 0.217 0.229 0.217 0.242 0.179 0.183 0.183 0.188 0.204 0.208	(mm/sec) Opening maximal velocity 72.675 165.634 154.145 147.801 114.059 160.339 124.445 102.886 131.867 138.837 178.304 171.331 143.831 143.596 143.309	(mm/sec) Closing maximal velocity 152.883 129.317 106.441 110.131 127.833 112.728 105.257 81.066 81.043 96.577 139.424 140.439 109.683 87.163 122.51	(mm) 0pening magnitude 18.707 16.746 16.466 19.6 18.025 17.284 16.527 15.427 15.427 15.427 15.427 15.747 16.591 18.79 17.584 16.591 18.79 17.584 16.814 13.211 16.388	opening-closing. Subject B, Wearing the complete mandibular denture with suction Name: D2
Stroke 1 2 3 4 5 6 7 8 9 10 11 12 13 14	(sec) 0pening-closing time 0.888 0.646 0.679 0.792 0.658 0.77 0.667 0.65 0.608 0.738 0.738 0.6 0.788 0.613 0.625	(sec) Occlusion time 0.279 0.267 0.275 0.238 0.258 0.283 0.229 0.263 0.313 0.217 0.454 0.242 0.271	(sec) Opening time 0.413 0.188 0.183 0.242 0.196 0.204 0.167 0.192 0.129 0.183 0.204 0.15 0.183 0.15	(sec) (losing time 0.196 0.275 0.225 0.238 0.217 0.229 0.217 0.242 0.179 0.242 0.179 0.188 0.204 0.208 0.225	(mm/sec) Opening maximal velocity 72.675 165.634 154.145 147.801 114.059 160.339 124.445 102.886 131.867 138.837 178.304 171.331 143.831 143.596 143.309 154.266	(mm/sec) Closing maximal velocity 152.883 129.317 106.441 110.131 127.833 112.728 105.257 81.066 81.043 96.577 139.424 140.439 109.683 87.163	(mm) 0pening magnitude 18.707 16.746 16.466 19.6 18.025 17.284 16.527 15.427 15.427 15.427 15.427 15.427 15.747 16.591 18.79 17.584 16.814 13.211	opening-closing. Subject B, Wearing the complete mandibular denture with suction Name: D2
Stroke 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17	(sec) 0pening-closing time 0.888 0.646 0.679 0.792 0.658 0.77 0.667 0.65 0.608 0.738 0.608 0.738 0.613 0.625 0.663 0.704 0.658	(sec) 0cclusion time 0.279 0.267 0.279 0.275 0.238 0.229 0.263 0.313 0.217 0.454 0.242 0.242 0.271 0.288 0.292 0.208	(sec) 0pening time 0.413 0.188 0.183 0.242 0.196 0.204 0.167 0.192 0.129 0.183 0.204 0.15 0.183 0.15 0.167 0.188 0.246	(sec) (losing time 0.196 0.275 0.225 0.238 0.217 0.229 0.217 0.242 0.179 0.242 0.179 0.183 0.188 0.204 0.208 0.225 0.204	(mm/sec) Opening maximal velocity 72.675 165.634 154.145 147.801 114.059 160.339 124.445 102.886 131.867 138.837 178.304 171.331 143.831 143.596 143.309 154.266 111.493	(mm/sec) Closing maximal velocity 152.883 129.317 106.441 110.131 127.833 112.728 105.257 81.066 81.043 96.577 139.424 140.439 109.683 87.163 122.51 93.12 122.827	(mm) 0pening magnitude 18.707 16.746 16.466 19.6 18.025 17.284 16.527 15.427 12.747 16.591 18.79 17.584 16.814 13.211 16.388 15.366 17.695	opening-closing. Subject B, Wearing the complete mandibular denture with suction Name: D2
Stroke 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18	(sec) 0pening-closing time 0.888 0.646 0.679 0.658 0.77 0.667 0.655 0.608 0.738 0.66 0.788 0.613 0.625 0.663 0.704 0.658 0.704	(sec) 0cclusion time 0.279 0.267 0.275 0.238 0.258 0.283 0.229 0.263 0.313 0.217 0.454 0.242 0.271 0.288 0.292 0.288 0.292 0.208 0.308	(sec) 0pening time 0.413 0.188 0.183 0.242 0.196 0.204 0.167 0.192 0.129 0.183 0.204 0.15 0.15 0.167 0.188 0.246 0.192	(sec) (losing time 0.196 0.217 0.225 0.238 0.217 0.229 0.217 0.242 0.179 0.242 0.179 0.183 0.188 0.204 0.208 0.204 0.204	(mm/sec) Opening maximal velocity 72.675 165.634 154.145 147.801 114.059 160.339 124.445 102.886 131.867 138.837 178.304 171.331 143.596 143.309 154.266 111.493 133.636	(mm/sec) Closing maximal velocity 152.883 129.317 106.441 110.131 127.833 112.728 105.257 81.066 81.043 96.577 139.424 140.439 109.683 87.163 122.51 93.12 122.827 91.366	(mm) 0pening magnitude 18.707 16.746 16.466 19.6 18.025 17.284 16.527 15.427 15.427 12.747 16.591 18.799 17.584 16.814 13.211 16.818 15.366 17.695 13.655	opening-closing. Subject B, Wearing the complete mandibular denture with suction Name: D2
Stroke 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19	(sec) 0pening-closing time 0.888 0.646 0.679 0.658 0.77 0.667 0.65 0.608 0.738 0.66 0.788 0.613 0.625 0.663 0.704 0.658 0.704 0.658	(sec) 0cclusion time 0.279 0.267 0.275 0.238 0.258 0.283 0.229 0.263 0.313 0.217 0.454 0.242 0.271 0.242 0.271 0.288 0.292 0.208 0.308 0.242	(sec) 0pening time 0.413 0.188 0.183 0.242 0.196 0.204 0.167 0.192 0.129 0.183 0.204 0.15 0.183 0.15 0.167 0.188 0.246 0.192 0.188	(sec) (losing time 0.196 0.217 0.275 0.225 0.238 0.217 0.229 0.217 0.242 0.179 0.242 0.179 0.183 0.188 0.204 0.204 0.204 0.204 0.204 0.225	(mm/sec) Opening maximal velocity 72.675 165.634 154.145 147.801 114.059 160.339 124.445 102.886 131.867 138.837 178.304 171.331 143.831 143.831 143.396 143.309 154.266 111.493 133.636 136.598	(mm/sec) Closing maximal velocity 152.883 129.317 106.441 110.131 127.833 112.728 105.257 81.066 81.043 96.577 139.424 140.439 109.683 87.163 122.51 93.12 122.827 91.366 128.543	(mm) 0pening magnitude 18.707 16.746 16.466 19.6 17.284 16.527 15.427 15.427 15.427 15.747 16.591 18.79 17.584 16.814 13.211 16.388 15.366 17.695 13.655 17.269	opening-closing. Subject B, Wearing the complete mandibular denture with suction Name: D2
Stroke 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18	(sec) 0pening-closing time 0.888 0.646 0.679 0.658 0.77 0.667 0.655 0.608 0.738 0.608 0.738 0.603 0.748 0.653 0.704 0.658 0.704 0.655 0.767	(sec) 0cclusion time 0.279 0.267 0.275 0.238 0.258 0.283 0.229 0.263 0.313 0.217 0.454 0.242 0.271 0.288 0.292 0.288 0.292 0.208 0.308	(sec) 0pening time 0.413 0.188 0.183 0.242 0.196 0.204 0.167 0.192 0.129 0.183 0.204 0.15 0.15 0.167 0.188 0.246 0.192	(sec) (losing time 0.196 0.217 0.225 0.238 0.217 0.229 0.217 0.242 0.179 0.242 0.179 0.183 0.188 0.204 0.208 0.204 0.204	(mm/sec) Opening maximal velocity 72.675 165.634 154.145 147.801 114.059 160.339 124.445 102.886 131.867 138.837 178.304 171.331 143.596 143.309 154.266 111.493 133.636	(mm/sec) Closing maximal velocity 152.883 129.317 106.441 110.131 127.833 112.728 105.257 81.066 81.043 96.577 139.424 140.439 109.683 87.163 122.51 93.12 122.827 91.366	(mm) 0pening magnitude 18.707 16.746 16.466 19.6 18.025 17.284 16.527 15.427 15.427 12.747 16.591 18.799 17.584 16.814 13.211 16.818 15.366 17.695 13.655	opening-closing. Subject B, Wearing the complete mandibular denture with suction Name: D2

complete mandibular denture with suction.

In this case of maxillo-mandibular edentulous patient, in comparison with wearing the complete mandibular denture without suction, all through the masticatory patterns of "rightlateral chewing", "left-lateral chewing" and "free chewing" of wearing the complete mandibular denture with suction exhibited time reduction of mouth opening-closing, enhanced magnitude of mouth opening, improvement of masticatory velocity, and stabilized masticatory rhythm. And because these data became close to those of the healthy dentulous subject, dynamic masticatory movement might be performed.

Meanwhile when wearing the complete mandibular denture

without suction, movement range was limited, closing motion took longer time and its velocity was delayed, showing a chopper type masticatory pattern. And so, in order to compensate the instability of the mandibular denture caused by pinching food bolus, it was assumed consequently that a slow and heavy jaw movement had dominated over in the vertical direction.

For a reason of shorter occlusion time at right-lateral chewing and free chewing when wearing the complete mandibular denture without suction, it may be related to low masticatory efficiency of the denture without suction, as it is reported that the rest time at the intercuspal position is likely to extend longer in the progress of mastication <sup>15)</sup>.

From this experimental study, it is suggested that wearing the complete mandibular denture with suction would be better effective in mastication than wearing the complete mandibular denture without suction.

Significant correlation was reportedly confirmed among aged patients between evaluation of denture performance and "dementia" or "degree of self-support" 16. 55% of patients in good performance of denture scores belonged to the group of "nondementia", but only 25% of poor denture scores belonged to this group. In addition, 50% of patients in good scores were in the group of "self-support", but only 22% of poor denture scores were in this group.

The fact shows that a good quality denture significantly contributes to a patient's health and QOL.

Facing an era of super-aging society, therapy of removable denture will be demanded more highly <sup>17</sup>, and good guality denture will have a profound effect on this society. Furthermore dentists will be also responsible for constructing good quality dentures.

Therefore, in a therapy of totally edentulous jaws, acquisition of techniques to construct a complete mandibular denture effective with suction onto the residual ridge should be indispensable in order to bring the Good News to edentulous patients.

## V. Conclusion

For maxillo-mandibular edentulous patients, in order to clarify the difference of masticatory movement of wearing the complete mandibular denture with suction or without suction respectively, same patient was instructed to chew same sort of test food and then the mandibular pathways and velocity were measured for comparative study, and the following conclusions were obtained.

1. As for the mouth opening-closing time in the masticatory movement, it was reduced when wearing the complete mandibular denture with suction in comparison with the complete mandibular denture without suction. But in some cases as far as only chewing time was concerned, contrary values were observed.

- 2. As for the magnitude of mouth opening while chewing, it was enhanced when wearing the complete mandibular denture with suction in comparison with the complete mandibular denture without suction.
- 3. As for the maximal velocity at mouth opening-closing, it showed higher values when wearing the complete mandibular denture with suction in comparison with the complete mandibular denture without suction.
- 4. As for the masticatory rhythm at masticatory movement, higher stability was shown when wearing the complete mandibular denture with suction in comparison with the complete mandibular denture without suction.
- 5. As for the masticatory pattern when wearing the complete mandibular dentures without suction or with suction respectively, both of them showed a grinding type, but wearing of the complete mandibular denture without suction tended to be a pattern of slightly chopper type.

As above, in the same maxillo-mandibular edentulous patient, the masticatory movement of wearing the complete mandibular denture without suction or with suction respectively showed apparent differences, and it was confirmed that the movement of wearing the complete mandibular denture with suction resembled that of healthy dentulous control.

Now therefore the masticatory movement when wearing the complete mandibular denture with suction is attained on more physiological and smooth performance, and in our super-aging society, acquisition of constructing denture suction technique for the complete mandibular denture should be essential to dentists.

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