Changes in the Duration of the Chewing Cycle in Patients With Skeletal Class III With and Without Asymmetry Before and After Orthognathic Surgery

Changes in the duration of chewing cycle of patients in skeletal class III with and without asymmetry before and after orthognathic surgery

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Purpose: The purpose of this study was to examine the changes in the chewing rhythm before and after mandibular ramus osteotomy for patients with prognathism with and without asymmetry.

Patients and Methods: twelve men and 22 women with mandibular prognathism were divided into groups on the basis of symmetry and osteotomy procedure. Preoperative and postoperative duration of chewing cycle were recorded. The duration of chewing cycle and coefficient variation were compared between groups and the differences were analyzed statistically.

Results: No significant differences in each of three phases of chewing cycle and total duration were found between groups on the basis of symmetry or osteotomy procedure. However, in the coefficienct of variation, there were significant differences between pre and post operation in the undeviated side in asymmetry group (P=0.0037) and SSRO group (P=0.0166).

Conclusion: This study suggests that surgical orthodontic treatment does not significantly change the duration of chewing cycle.

Key words: chewing cycle, asymmetry, sagittal split ramus osteotomy, intraoral vertical ramus osteotomy

Introduction

Mandibular ramus osteotomy induces morphological changes, but it remains unclear whether it induces improvements in all functions. Surgical orthodontic correction of skeletal class III physiology reportedly has favorable effects on the function of the mandible, such as an increased ranges of maximum motion in anterior, posterior, and lateral excursion[1]. Studies regarding the opening and closing movements[2,3] showed significant improvement after mandibular setback surgery. However, in some studies, chewing efficiency improved after surgical correction but did not reach control values.[4,5] In other studies, improvement could not be shown.[6,7,8]

When the chewing movement of mandibular prognathism is examined, the presence or absence of symmetry must be distinguished, because the incidence of internal derangement is higher in patients with asymmetrical class III than in patients with symmetrical mandibular prognathism. Although bilateral temporomandibular joint morphology is similar among cases with symmetry, it is noticeably different among cases with asymmetry[9]. In particular, the degree of mandibular deviation along the condylar long axis varies with mandibular movement[10]. Moreover, some researchers have reported that subjects with mandibular deviation have an asymmetrical sagittal condylar path angle and an asymmetrical length and curvature of the anterior condylar path[11-13]. Therefore, it is important to assess the relationship between maxillofacial morphology and gnathological function in patients with prognathism on the basis of symmetry or asymmetry. It remains unclear whether changes in the chewing cycle depend on the surgical procedure performed.

The purpose of this study was to examine the chewing cycle after mandibular ramus osteotomy in patients with skeletal class III physiology with and without symmetry, and to distinguish the results by surgical procedure between sagittal split ramus osteotomy (SSRO) and intraoral vertical ramus osteotomy (IVRO).

Patients and Methods

Patients

Twelve men and 22 women (average age, 23.6±6.1 years) with mandibular prognathism without severe temporomandibular joint dysfunction underwent either sagittal split ramus osteotomy (SSRO) or intraoral vertical ramus osteotomy (IVRO). Although all cases were diagnosed as skeletal class III on the basis of lateral cephalogram analysis, asymmetry needed to be taken into account for accurate frontal cephalogram analysis. In the frontal cephalogram, the angle between the ANS-Menton line and the line perpendicular to the bilateral zygomatic frontal suture line was defined as the Mx-Md midline angle. A positive value of this Mx-Md midline angle represents mandibular deviation to the left, and a negative value of this angle represents mandibular deviation to the right (Fig. 1). The Mx-Md midline angles of all cases were then given a positive value so that all consecutive measurements could be attributed to either the deviated or the undeviated side.

The patients were divided into two groups on the basis of the Mx-Md midline angulation. The asymmetry group consisted of those in whom the Mx-Md midline angle was greater than 2.5 degrees (n=19), and in the symmetry group, the Mx-Md midline angle measured less than 2.5 degrees (n=15).

Furthermore, to evaluate the difference related to surgical procedure, we separated the subjects into groups by surgical procedure: the SSRO group (n=22) and the IVRO group (n=12). All patients in IVRO group belonged to asymmetry group. However, the remaining 7 patients with asymmetry could be performed SSRO, because the interference between bony segments did not occur from the result of preoperative simulation. All patients in symmetry group were SSRO group.

The preoperative and postoperative duration of chewing cycle were recorded using the Sirognathograph Analyzing System II (Tokyo shika sangyou, Tokyo, Japan)[10,14]. Recording was carried out before preoperative orthodontic treatment and after postoperative orthodontic treatment without a multi-bracket system (approximately 1 year after surgery). The recording magnets were fixed at the centers of the right and left lower incisor margins with a liquid adhesive. The subjects were seated upright with no restriction of the head, and with Sirognatho-antenna parallel to the Frankfort horizontal (FH) plane. Masticatory movements on the right and left sides were recorded for 30 seconds after subjects had been given a chance to soften up the chewing gum used for this purpose. 20 strokes after the fifth stroke were recorded and the average duration of chewing cycle (that consisted of opening, closing and occluding phase) was calculated. Furthermore, the coefficient of variation (standard deviation / average ×100) in each phase of chewing cycle was used to evaluate the stability of chewing motion (Fig. 2).

The duration of the chewing cycle and coefficient of variation were compared between groups and differences were analyzed statistically with t-test and paired t-test with StatView™ software, version 4.5 (Abacus Concepts, Inc., Berkeley, CA, USA). The differences were considered significant at $p<0.05$.

Results

No significant differences were found in the duration of chewing cycle between pre and post-operation in SSRO group, IVRO group, the asymmetry group and the symmetry group. No significant differences were found in the duration of chewing cycle between deviated side and undeviated side in pre and postoperative SSRO group, IVRO group, the asymmetry group and the symmetry group (Table 1).

However, in the comparison of coefficient of variation, the postoperative value of occluding time was significantly smaller than preoperative one in undeviated side (P=0.0358) and there was significant difference in occluding time between deviated and undeviated side postoperatively in asymmetry group (P=0.0037).

In symmetry group, there were no significant differences between pre and post-operation, and between deviated and undeviated side in coefficient variation of all phases of chewing cycle.

In IVRO group, although there was no significant difference in coefficient variation of occluding time between deviated and undeviated side preoperatively, the coefficient of variation of occluding time in deviated side was larger than that in undeviated side postoperatively (P=0.0406).

In SSRO group, although, the coefficient of variation of occluding time in deviated side was larger than that in undeviated side preoperatively (P=0.0318), there was no significant difference between deviated and undeviated side postoperatively. The postoperative coefficient of variation of occluding time was smaller than preoperative one in undeviated side (P=0.0166).

When the data was calculated statistically as a total group, the coefficient of variation of occluding time in deviated side was smaller than that in undeviated side preoperatively (P=0.0459), however, that in deated side was larger than that in undeviated side postoperatively (P=0.0308). The postoperative coefficient of variation of occluding time was smaller than preoperative one in undeviated side (P=0.0167) (Table 2).

Discussion

The functional improvement following orthognathic surgery is expected as well as cosmetic improvement, and many studies have documented masticatory functions such as masticatory efficiency[5,6], muscle activity[15], bite force[16], and occlusal contacts[17-19].

The chewing cycle is defined as a series of mandibular movement consisted of opening phase, closing phase and occluding phase. The chewing rhythm shows the regularity of repetition of the chewing cycle. Therefore, the chewing rhythm includes many times chewing cycles, the standard deviation and the coefficient of variation. The coefficient of variation shows the stability of chewing rhythm. These data can be used as one of the factor show the functional improvement. If the duration of chewing cycle and the coefficient of variation decrease postoperatively, we can interpret the improvement in chewing movement can be achieved.

In patients with mandibular retrognathia, chewing performance was not influenced by orthodontics before surgery, and it was impaired with respect to that of control subjects before surgery[20]. This finding was consistent with results obtained from groups of patients with a variety of dentfacial deformities[4,7] and in patients mandibular prognathism[5,6,8]. Some previous studies concluded that at least 1 year after mandibular advancement surgery, chewing performance was not improved[21]. However, in other studies containing mandibular setback patients, improvement was shown[5,8,22]. Pröschel et al[23]. reported an increase of 0.01 sec in the duration of opening and closing durations after surgical correction of 22 prognathic patients. However, this postoperative increase was not statistically different from the patients' durations before surgery, and such a small increase would also not be clinically significant. Fuji et al[24]. reported that there was no difference in chewing cycle time among pre, postoperative and control group, in mandibular setback surgery cases. Theses results were in accordance with our findings, although asymmetry cases were not included in the previous studies.

In this study, we recorded and examined habitual chewing movement in groups divided by frontal, on both the deviated and undeviated sides of the chewing movement, making comparisons with these studies difficult. However, there were no significant differences between symmetry and asymmetry group, and between IVRO and SSRO group, pre and postoperatively in the duration of chewing cycle. Furthermore, there was also no significant difference between deviated and undeviated side in each group. These results might be affected by much variation of chewing movement.

On the other hand, Fujii et al[24] stated that the postoperative coefficient of variation of total duration chewing cycle was significantly smaller that preoperative value. Kobayashi et al[8] also reported that the preoperative mean coefficients of variation decreased significantly postoperatively using electromyography. In this study, in the coefficient of variation in occluding time, postoperative significant decrease was found in the undeviated side in asymmetry group and SSRO group. The coefficient of variation could be interpreted as stability of the value so that these results could be considered that just postoperative occluding time became more stable than preoperative one, although total the coefficient of variation in total chewing cycle did not change. The improvement in the coefficient of variation in undeviated side in asymmetry group and SSRO group might show the possibility of equalization of habitual chewing in both sides. Occlusion and skeletal change by orthognathic surgery may induce the change in the stability of chewing rhythm.

Interestingly, after surgery, the coefficient of variation in deviated side was higher than that in undeviated side in asymmetry group and IVRO group. The patients who underwent IVRO had almost asymmetry so that this result could be considered as the result of asymmetry cases. If the habitual chewing side was deviated side, these results could be understandable. Preoperative chewing rhythm was comparatively stable in bilateral side, however, postoperative one in deviated side showed a tendency to be worse and that in undeviated side significantly became better. This suggested that the postoperative rate of chewing in undeviated might be higher than preoperative one. In our previous study[25], of the components of the chewing path, the incisal path angle of the chewing path on the deviated side showed a significantly higher value than that on the undeviated side in both the symmetry and asymmetry groups before and after treatment. This change in the chewing path also might affect the significant change in the coefficient of variation of chewing cycle.

In conclusion, this study suggests that surgical orthodontic treatment does not significantly change the duration of chewing cycle, although postoperative stability of chewing cycle was implied in undeviated side in asymmetry group and SSRO group. However, because this study was performed with a small number of subjects, further examination with a large number of subjects will be necessary.

References

1) Nagamine T, Kobayashi T, Nakajima T, Hanada K: The effects of surgical-orthodontic correction of skeletal class III malocclusion on mandibular movement. J Oral Maxillofac Surg 51: 385, 1993.
2) Aragn SB, Van Sickels JE, Dolwick MF, et al.: The effects of orthognathic surgery on mandibular range of motion. J Oral Maxillofac Surg 43: 938, 1985.
3) Boyd SB, Karas ND, Sinn DP: Recovery of mandibular mobility following orthognathic surgery. J Oral Maxillofac Surg 49: 924, 1991.
4) Ästrand P: Chewing efficiency before and after surgical correction of developmental deformities of the jaws. Swed Dent J 67:135, 1974.
5) Shiratsuchi Y, Kouno K, Tashiro H: Evaluation of masticatory function following orthognathic surgical correction of mandibular prognathism. J Cranio-Maxillofac Surg 19: 299, 1991.
6) Kobayashi T, Honma K, Nakajima T, Hanada K: Masticatory function in patients with mandibular prognathism before and after orthognatic surgery. J Oral Maxillofac Surg 51: 997, 1993.
7) Zarrinkelk HM, Throckmoton GS, Ellis III, et al: A longitudinal study of the changes in masticatory performance of patients undergoing orthognathic surgery. J Oral Maxillofac Surg 53: 777, 1995.
8) Kobayashi T, Honma K, Shingaki S, et al: Change in masticatory function after orthognathic treatment in patients with mandibular prognathism. Br J Oral Maxillofac Surg 39:260, 2001.
9) Ueki K, Nakagawa K, Takatsuka S, et al: Temporomandibular joint morphology

and disc position in skeletal class III patients. J Cranio-Maxillofac Surg 28: 362, 2000.

10) Tomoyose Y, Bandai H, Sugiwara J, Mitani H: Characteristics of chewing path in skeletal class III patients with mandibular asymmetry. Orthod Waves 61: 376, 2002.

11) Mimura H, Deguchi T: Relationship between sagittal condylar path and the degree of mandibular asymmetry in unilateral crossbite patients. Cranio 12: 161, 1994.

12) Pirttiniemi P, Kantomaa T, Lahtela P: Relationship between craniofacial and condyle path asymmetry in unilateral crossbite patients. Eur J Orthod 12: 408, 1991.

13) Fukui T, Satoh Y, Yamada K, Morita S, Hanada K: Relationship between mandibular lateral deviation and bilateral condylar paths on mandibular protrusive movement. J Jpn Orthod Soc 51: 203, 1992.

14) Youssef RE, Throckmorton GS, Ellis III E, Sinn DP: Comparison of habitual masticatory cycle and muscle activity before and after orthognathic surgery. J Oral Maxillofac Surg 55: 699, 1997.

15) Raustia AM, Oikarinen KS: Change in electric activity of masseter and temporal muscles after mandibular sagittal split osteotomy. Int J Oral Maxillofac Surg 23: 180, 1994.

16) Ellis E, Throckmorton GS, Sinn DP: Bite forces before and after surgical correction of mandibular prognathism. J Oral Maxillofac Surg 54: 176, 1996.

17) Throckmorton GS, Buschang PH, Ellis E: Improvement of maximum occlusal

forces after orthognathic surgery. J Oral Maxillofac Surg 54: 1080, 1996.

18) Kim YG, Oh SH: Effect of mandibular setback surgery on occlusal force. J Oral Maxillofac Surg 55:121, 1997.

19) Iwase M, Sugimori M, Kurachi Y, Nagumo M: Changes in bite force and occlusal contacts in patients treated for mandibular prognathism by orthognathic surgery. J Oral Maxillofac Surg 56: 850, 1998.

20) van den Braber W, van der Glas H, van der Bilt A, et al: The influence of orthodontics on selection and breakage underlying food comminuition in pre-orthognathic surgery patients. Int J Oral Maxillofac Surg 31: 592, 2002.

21) van den Braber W, van der Glas H, van der Bilt A, et al: Masticatory function in retrognathic patients, before and after mandibular advancement surgery. J Oral Maxillofac Surg 62: 549, 2004.

22) Kikuta T, Hara I, Seto T, et al: Evaluation of masticatory function after sagittal split ramus osteotomy for patients with mandibular prognathism. Int J Adult Orthod Orthognath Surg 9: 9, 1994.

23) Proschel PA, Hummer H, Hofmann M, Spitzer W: Reaction of mastication to occlusal changes induced by correction of mandibular prognathism. J Prosthet Dent 64: 211, 1990.

24) Fujii T, Sugawara J, Kuwahara S et al: Long-term postoperative evaluation of chewing rhythm in skeletal Class III patients undergone surgical-orthodontic treatment 54: 227, 1995.

25) Ueki K, Marukawa K, Shimada M, et al: Changes in the chewing path of patients in skeletal class III with and without asymmetry before and after orthognathic

surgery. J Oral Maxillofac Surg 63: 442, 2005.

Legend

Fig. 1 Mx-Md midline in frontal cephalogram

Fig. 2 Typical record of frontal chewing path and chewing cycle. Mean shows mean duration of 20 chewing cycle. S.D. shows standard deviation. C.V. shows coefficient of variation. Chewing rhythm includes the mean of 20 strokes of chewing cycle, the standard deviation and the coefficient of variation.

Table 1. Mean duration and standard deviation (SD) of chewing cycle (opening, closing and occluding phase). SD*: shows mean of standard deviation of individual 20 strokes chewing cycle.

Table 2. Mean and standard deviation (SD) of coefficient of variation in chewing cycle (opening, closing and occluding phase). *: shows significant difference between deviated and undeviated side at $P<0.05$. **: shows significant difference between before and after surgery at $P<0.05$.

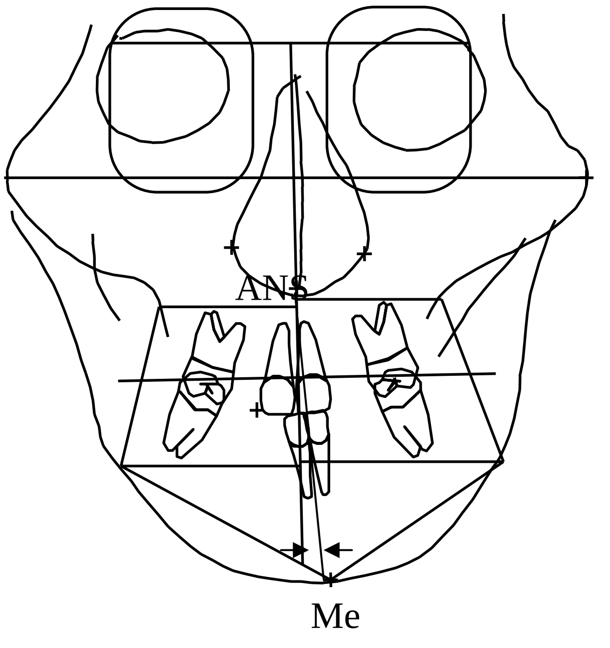
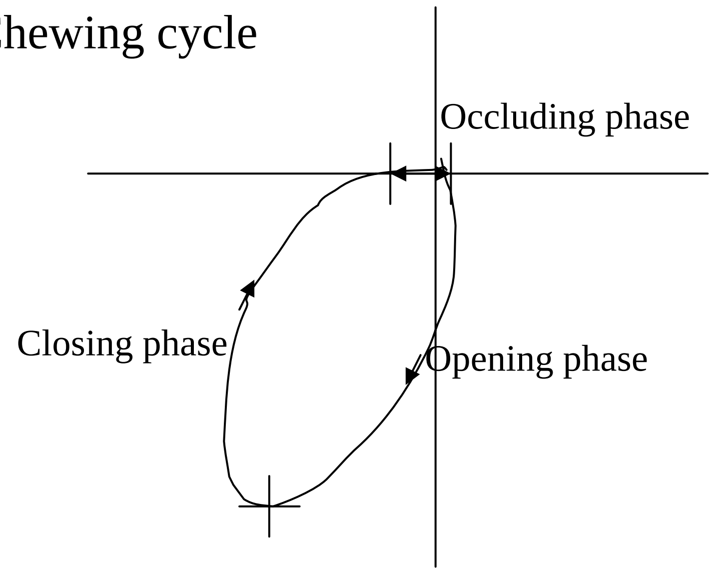


Fig.1

Chewing cycle



Chewing rhythm

	Mean (sec)	S.D.	C.V.
Opening phase (n=20)	0.277	0.060	21.661
Closong phase (n=20)	0.230	0.024	10.435
Occluding phase (n=20)	0.218	0.046	21.101
Cycle time (n=20)	0.725	0.081	11.172

Fig.2

			Before								After							
			opening (msec)	closing (msec)	occluding (msec)	cycle (msec)	opening SD*	closing SD*	occluding SD*	cycle SD*	opening (msec)	closing (msec)	occluding (msec)	cycle (msec)	opening SD*	closing SD*	occluding SD*	cycle SD*
Asymmetry group	Deviated side	Average	310.2	287.5	251.2	848.9	71.4	55.7	45.6	90.2	280.2	297.6	253.7	831.6	58.6	48.6	62.5	83.7
		SD	56.0	61.5	86.1	151.9	31.6	41.9	20.8	47.4	57.0	86.4	87.4	188.0	19.9	20.2	57.3	44.1
	Undeviated side	Average	297.4	284.4	243.8	825.8	59.3	51.5	48.3	81.8	295.5	293.3	246.9	835.6	57.2	54.6	35.3	75.1
		SD	58.0	70.6	80.3	153.5	28.5	24.2	27.0	41.4	67.7	74.5	71.6	170.8	31.1	30.6	20.7	33.8
Symmetry group	Deviated side	Average	317.9	281.7	229.6	829.1	66.9	51.5	44.1	89.7	302.5	277.9	253.0	833.5	78.7	62.2	40.0	102.3
		SD	67.3	40.6	60.3	105.2	34.8	26.5	22.6	52.9	58.1	47.3	64.7	114.6	38.0	54.5	18.8	81.5
	Undeviated side	Average	313.3	269.9	237.0	820.3	75.3	53.7	66.3	103.3	303.9	285.9	248.9	838.5	70.1	71.5	41.7	116.4
		SD	67.3	49.1	55.8	112.7	36.5	22.9	62.0	64.8	46.3	60.2	57.0	106.0	36.6	65.6	18.9	81.7
IVRO group	Deviated side	Average	310.4	283.7	244.4	838.7	72.8	53.1	44.4	89.9	269.5	265.1	251.5	786.2	63.7	62.8	55.3	104.3
		SD	61.4	62.6	71.7	149.8	30.1	43.3	22.5	40.5	50.4	59.4	63.6	139.9	31.2	61.4	36.4	80.0
	Undeviated side	Average	307.8	273.3	251.3	832.2	70.9	52.6	46.0	99.7	298.1	261.2	249.5	808.7	68.3	44.2	41.6	91.3
		SD	67.6	49.3	85.2	159.2	48.1	25.3	31.4	55.1	77.7	54.2	55.2	170.2	42.2	17.1	23.8	43.0
SSRO group	Deviated side	Average	315.3	285.6	240.1	841.0	67.6	54.3	45.3	90.0	301.2	301.9	254.5	857.6	69.5	50.1	51.0	85.1
		SD	61.2	47.9	79.2	124.8	34.4	31.5	21.1	54.1	59.5	75.4	85.0	164.1	30.7	19.2	50.5	52.4
	Undeviated side	Average	302.5	280.6	235.1	818.6	63.9	52.4	61.8	86.7	299.8	305.8	246.9	852.3	59.9	71.8	36.2	94.5
		SD	60.0	68.4	61.0	123.9	21.5	22.8	52.1	52.9	47.1	70.2	70.5	128.9	28.8	57.9	17.8	71.7
total	Deviated side	Average	313.6	284.9	241.6	840.2	69.4	53.9	45.0	90.0	290.0	288.9	253.4	832.4	67.5	54.6	52.6	91.9
		SD	60.4	52.6	75.5	131.9	32.6	35.5	21.3	49.1	57.7	71.5	77.1	157.7	30.5	39.1	45.5	63.0
	Undeviated side	Average	304.4	278.0	240.8	823.4	66.4	52.5	56.2	91.3	299.2	290.0	247.8	836.9	62.9	62.0	38.1	93.3
		SD	61.8	61.6	69.7	135.1	32.8	23.4	46.0	53.2	58.5	67.7	64.6	143.8	33.7	49.1	19.9	62.3

Table 1.

			Before					After				
			opening (%)	closing (%)	occluding (%)	sig.	cycle (%)	opening (%)	closing (%)	occluding (%)	sig.	cycle (%)
Asymmetry group	Deviated side	Average	28.5	19.2	18.1		10.5	20.8	16.4	22.8		9.9
		SD	12.8	13.5	5.5		4.9	6.1	4.3	13.0	*	3.7
	Undeviated side	Average	19.2	18.2	19.5	**	9.7	18.8	19.6	14.3	**	9.5
		SD	6.8	8.0	7.6		4.5	8.2	13.2	6.7		5.1
Symmetry group	Deviated side	Average	28.8	18.2	19.5		10.9	25.8	22.3	16.1		12.1
		SD	17.5	8.9	8.9		6.8	12.3	18.8	6.9		9.1
	Undeviated side	Average	23.9	20.0	27.6		13.1	23.3	24.0	16.8		13.7
		SD	8.7	8.3	23.4		9.0	11.2	16.1	6.1		8.7
IVRO group	Deviated side	Average	28.1	18.0	17.7		10.5	23.1	22.9	21.8		12.7
		SD	10.0	11.4	5.4		4.0	9.8	20.4	13.1	*	7.9
	Undeviated side	Average	21.5	19.4	17.5		11.7	21.9	18.5	16.1		11.4
		SD	11.0	9.9	8.0		5.8	10.8	13.0	7.1		5.1
SSRO group	Deviated side	Average	28.9	19.2	19.3		10.8	23.0	16.9	18.8		9.9
		SD	17.1	11.9	7.9	*	6.6	9.6	5.9	10.1		5.8
	Undeviated side	Average	21.2	18.8	26.1	**	11.0	20.2	23.2	15.0	**	11.3
		SD	5.9	7.2	19.5		7.6	9.3	15.3	6.2		8.2
total	Deviated side	Average	28.6	18.8	18.7		10.7	23.0	19.0	19.8		10.9
		SD	14.8	11.6	7.1		5.7	9.5	13.0	11.1	*	6.6
	Undeviated side	Average	21.3	19.0	23.1	**	11.2	20.8	21.6	15.4	**	11.3
		SD	7.9	8.1	16.7		7.0	9.7	14.5	6.5		7.1

Table 2.