Assessment of the Relationship Between the Recovery of Maximum Mandibular Opening and the Maxillomandibular Fixation Period After Orthognathic Surgery

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Abstract

Purpose: The purpose of this study was to evaluate the differences in the recovery of maximum mandibular opening (MMO), and the relationship between MMO and the maxillomandibular fixation (MMF) period after sagittal split ramus osteotomy (SSRO) and intraoral vertical ramus osteotomy (IVRO), with and without Le Fort I osteotomy.

Subjects and Methods: Sixty-eight patients with diagnosed mandibular prognathism with or without asymmetry were divided into four groups (SSRO, IVRO, SSRO with Le Fort I osteotomy, and IVRO with Le Fort I osteotomy). MMO and the MMF period were measured preoperatively and at 1-, 3-, 6-, 12-, and 18- months after surgery. The differences among surgical procedures and the relationship between MMO and the MMF period were examined statistically.

Results: In relation to time-dependent changes in MMO, there were no significant differences among the groups. There were significant positive correlations between MMO and the MMF period from 1 month to 6 months after surgery. However, there were no significant correlations at 12- and 18- months after surgery.

Conclusion: This study suggests that there were no significant differences between single-jaw surgery and double-jaw surgery in terms of postoperative time-dependent changes in the recovery of MMO. However, the MMF period was associated with the recovery of MMO.

Introduction

The time taken to recover mandibular mobility following orthognathic surgery is one of the important factors governing the selection of operative procedures. Several investigators have reported alterations in mandibular mobility following orthognathic surgery.[1–8] This can occur to a greater or lesser extent following mandibular and maxillary surgery.[4,6] Methods including intra-operative fixation of bony segments, postoperative intermaxillary fixation, and myotomy of the suprahyoid musculature may influence the degree of hypomobility.[6,9,10] In a previous study, the use of bone screw fixation was attributed to an improvement in a range of movements to achieve early jaw mobilization, which avoided the deleterious effects of immobilization on the masticatory musculature and associated connective tissue.[2]

Sagittal split ramus osteotomy (SSRO) has become one of the preferred surgical procedures for the correction of various jaw deformities. However, its alternative intraoral vertical ramus osteotomy (IVRO), has also become a common procedure.[11] In the correction of mandibular prognathism, SSRO with rigid fixation has several advantages over IVRO with maxillomandibular fixation (MMF), including a larger bony interface between the segments, easier fixation, and earlier healing as a result. Therefore, SSRO can provide immediate postoperative jaw mobilization without MMF. Furthermore, Le Fort I osteotomy is also used very frequently with SSRO or IVRO for orthognathic surgery,[12] although the purpose for applying this procedure varies.

The recovery of maximum mandibular opening (MMO) is an important factor determining which surgical procedure is selected. MMO measurement is easier to

understand and it can show statistical differences more readily than protrusive and lateral excursion measurements.[8] However, there were no reports that statistically evaluate the relationship between the recovery of MMO and the MMF period after orthognathic surgery. Although it is very important to understand the recovery of MMO after different orthognathic procedures, there is still no evidence to suggest whether particular surgical procedures and the MMF period affect the recovery of the MMO.

The purpose of this study was to evaluate the differences in the recovery of MMO, and the relationship between MMO and the MMF period after SSRO and IVRO, with and without Le Fort I osteotomy.

Patients and Methods

This retrospective study comprised 68 randomly selected patients (19 men and 49 women, mean age, 23.5 ± 6.0 years; range 16–41 years). Their conditions were diagnosed as mandibular prognathism, mandibular prognathism with mandibular asymmetry, and mandibular prognathism with bimaxillary asymmetry. None of the patients had severe temporomandibular joint disorder. The surgical procedure was determined after the patients had given their informed consent. The subjects were divided into four groups. Group 1 consisted of 17 patients who underwent bilateral SSRO (using the Obwegeser-Dal Pont or Obwegeser method) with rigid fixation using mini-plates and monocortical screws. Group 2 consisted of 17 patients who underwent IVRO without segmental fixation. Group 3 consisted of 17 patients who underwent

SSRO and Le Fort I osteotomy. Group 4 consisted of 17 women who underwent IVRO and Le Fort I osteotomy. All patients received MMF with intermaxillary fixation screws (Stryker Leibinger, Freiburg, Germany) in the region of the anterior teeth. After MMF, sequential elastic traction was performed to maintain the ideal occlusion. All patients received orthodontic treatment before and after surgery.

Measurements

Mandibular mobility was recorded manually using a millimeter ruler. MMO was measured to the nearest millimeter, compensating for overjet and overbite according to a previous report.[13] MMO and the MMF period were measured preoperatively and at 1-, 3-, 6-, 12-, and 18- months after surgery.

Statistical Analysis

MMO and the MMF period data were statistically analyzed with Dr. SPSS II software (SPSS Japan Inc., Tokyo, Japan). Time-dependent changes (times × group) were examined using analysis of variance (repeated measures ANOVA), and multiple comparisons were adjusted using the Bonferroni correction. The relationship between MMO and the MMF period was examined using simple regression analysis of each period.

Results

In all groups, MMO was at the lowest value 1 month after surgery. Although it increased gradually, MMO 18 months after surgery remained lower than the preoperative level in all groups (Fig. 1). No significant differences were found for MMO among the four groups at each postoperative period. The mean MMF period (± SD) was 4.8 ± 2.7 days in group 1, 11.9 ± 4.8 days in group 2, 6.7 ± 1.8 days in group 3, and 14.6 ± 5.8 days in group 4.

Within group 1, the preoperative MMO was significantly larger than the MMO at 1- ($p < 0.0001$), 3- ($p < 0.0001$), and 6- ($p = 0.012$) months after surgery. However, there were no significant differences between the preoperative MMO and the MMO 12- and 18- months after surgery.

Within group 2, the preoperative MMO was significantly larger than the MMO at 1- ($p < 0.0001$), 3- ($p < 0.0001$), and 6- ($p = 0.002$) months after surgery. However, there were no significant differences between the preoperative MMO and the MMO 12- and 18- months after surgery.

Within group 3, the preoperative MMO was significantly larger than the MMO at 1- ($p < 0.0001$), 3- ($p < 0.0001$), 6- ($p = 0.001$), and 12- ($p = 0.027$) months after surgery. However, there was no significant difference between the preoperative MMO and the MMO at 18 months after surgery.

Within group 4, the preoperative MMO was significantly larger than the MMO at 1- ($p < 0.0001$), 3- ($p < 0.0001$), 6- ($p = 0.001$), and 12- ($p = 0.030$) months after surgery. However, there was no significant difference between the preoperative MMO

and the MMO at 18 months after surgery.

No significant differences were found among the groups regarding the time-dependent changes in the MMO. However, the time-dependent changes within subjects in all groups showed significant differences using ANOVA (Fig.1 and Table 1).

The results of the statistical analysis of the relationship between the MMO and MMF period in each postoperative period follow. Significant correlations were found between the MMO at 1 month after surgery and the MMF period (R = 0.315, adjusted R2 = 0.090, RMS Residual = 5.005, p = 0.0018), between the MMO at 3 months after surgery and the MMF period (R = 0.214, adjusted R2 = 0.035, RMS Residual = 5.152, p = 0.0367), and between the MMO at 6 months after surgery and the MMF period (R = 0.221, adjusted R2 = 0.039, RMS Residual = 5.143, p = 0.0305). However, no significant correlations were found between the MMO at 12 months after surgery and the MMF period (R = 0.199, adjusted R2 = 0.030, RMS Residual = 5.168, p = 0.0514), and between the MMO at 18 months after surgery and the MMF period (R = 0.179, adjusted R2 = 0.022, RMS Residual = 5.199, p = 0.0832) (Figs 2-6).

Discussion

Mandibular hypomobility has been reported most frequently in individuals who have undergone SSRO for mandibular advancement that has been stabilized by dental fixation. Aragon and Van Sickels reported a significant reduction in the magnitude of this hypomobility following the use of bone screw fixation.[2] Ellis demonstrated the same improvement in postoperative mobility when comparing bone screw fixation to dental fixation following SSRO in monkeys.[14]

Zimmer *et al.*[15] reported that maxillary advancement by Le Fort I osteotomy, and two-jaw surgery and mandibular setback osteotomy did not influence mandibular mobility permanently. A closer similarity in recovery of mobility was seen between the Le Fort I osteotomy group and the two-jaw surgery group, than between the sagittal split groups (mandibular advancement or a two-jaw surgery/mandibular setback), indicating that the problem of reduced mobility after orthognathic surgery can be limited to Class II therapy. In contrast, in Class III therapy, the application of rigid fixation in combination with a method of maintaining condyle position guarantees a rapid recovery to preoperative levels of mandibular mobility. However, it has been reported that there was no significant difference in the range of movements between rigid and non-rigid fixations of bilateral sagittal split osteotomies in Class II patients.[16,17] Nishimura *et al.*[18] also reported that the initial interincisal distance was greater in the positional screw group, followed by the miniplate, circumferential wire, and the lag screw groups. However, there were no significant differences in the initial interincisal distance among these groups. They concluded that the procedures or

techniques of osteosynthesis did not appear to greatly influence mouth opening shortly after setback SSRO for Class III patients.

In a previous study by Boyd *et al.*[8] a significant reduction in MMO occurred immediately after surgery in the Le Fort I osteotomy and SSRO groups and at lease of fixation in the IVRO group. They stated that significant differences in the recovery patterns of mandibular mobility exist between surgical procedures. Since the Le Fort I osteotomy group had no direct trauma to the temporomandibular joint or masticatory musculature, they recovered quickly in this study. However, the study did not address double-jaw surgery.

Our study involved two types of double-jaw surgery and two types of single-jaw surgery. This study demonstrated that there were no significant differences among the four patient groups, suggesting that the addition of Le Fort I osteotomy does not affect the recovery of MMO, as mentioned previously.[8]

Previous studies indicate that intrinsic differences exist between SSRO and IVRO patients when dental fixation is used without physiotherapy, with IVRO patients recovering a larger percentage of their preoperative MMO.[3,4] It was considered that the difference in the recovery of MMO between the SSRO and IVRO groups depended on the period of MMF after surgery. In this study, there were no significant differences in the recovery of MMO not only between the SSRO and IVRO groups, but also between the SSRO with Le Fort I osteotomy group and the IVRO with Le Fort I osteotomy group. This may be due to the shorter MMF period in the IVRO group and the IVRO with Le Fort I osteotomy group in this study compared with other studies.

When the subjects were not divided according to procedures in this study there were

significant correlations between the MMO and the MMF period 1-, 3-, and 6- months after surgery and there were no significant correlations between the MMO and the MMF period 12- and 18- months after surgery. This suggests that the MMF period could affect the MMO in the time period from immediately after surgery to 6 months after surgery. However, the MMF period could not affect the MMO 1 year postoperatively.

In fact, SSRO with rigid fixation has several advantages over IVRO with MMF, including a larger bony interface between the segments, easier fixation, and earlier healing as a result.[11] Even if patients undergo IVRO, we could make the MMF period shorter (to a minimum of 3 days). Furthermore, recently we found that a stable occlusion could be obtained by just using elastic traction without MMF, thereby reducing the hospitalization period.

The study by Storum and Bell[3] that compared pre- and post- surgical MMO, lateral and protrusive mandibular movements, maximum bite force, muscle fatigability, and the clinical evaluation of the temporomandibular joints between a rehabilitation group and a non-rehabilitation group, showed no significant difference between IVRO with and without rehabilitation, but SSRO with rehabilitation showed a significant increase in mean mandibular opening and bite force. However, their study included 6 weeks of MMF immobilization followed by muscular rehabilitation in the IVRO group, which was much longer than the MMF period in our study.

The incidence of limited opening and degenerative changes in the temporomandibular joint has previously been associated with the duration of MMF.[19] Atrophy of human skeletal muscle (types I and II) and a decrease in strength and

muscle energy stores have also been associated with immobilization.[20] However, these effects were shown to be transient and reversible in an animal study, as the muscle fibers could completely recover after 6 weeks of immobilization.[21]

Postsurgical physical rehabilitation after ramus osteotomy is important, but it is more important to attempt to shorten the MMF period. Two patients experienced dislocation of the proximal segment including the condyle 1 day after surgery, but these cases were not included in this study. Therefore, for at least 1 week after IVRO, mandibular mobilization including the sliding movement of the condyle should be avoided, because dislocation of the condyle can occur. However, it is considered that MMF is not necessary. If we can teach patients how to establish the postoperative occlusion themselves and they can understand the postoperative situation, elastic traction immediately after surgery is sufficient to maintain the postoperative occlusion. From the results of this study, shortening the MMF period might promote the recovery of mandibular movement so surgeons should try to make the MMF period shorter, even if IVRO without internal rigid fixation is performed.

In conclusion, we suggest that there are no significant differences between single-jaw surgery and double-jaw surgery in relation to postoperative time-dependent changes as they relate to the recovery of MMO. However, the MMF period was associated with the recovery of MMO.

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Legend

Fig. 1. Time-course changes in mean MMO. Error bars indicate the standard deviation.

Fig. 2. Result of a simple regression analysis between MMO after 1 month and the MMF period.

Fig. 3. Result of a simple regression analysis between MMO after 3 months and the MMF period.

Fig. 4. Result of a simple regression analysis between MMO after 6 months and the MMF period.

Fig. 5. Result of a simple regression analysis between MMO after 12 months and the MMF period.

Fig. 6. Result of a simple regression analysis between MMO after 18 months and the MMF period.

Table 1. Time-course changes in mean MMO and standard deviation.

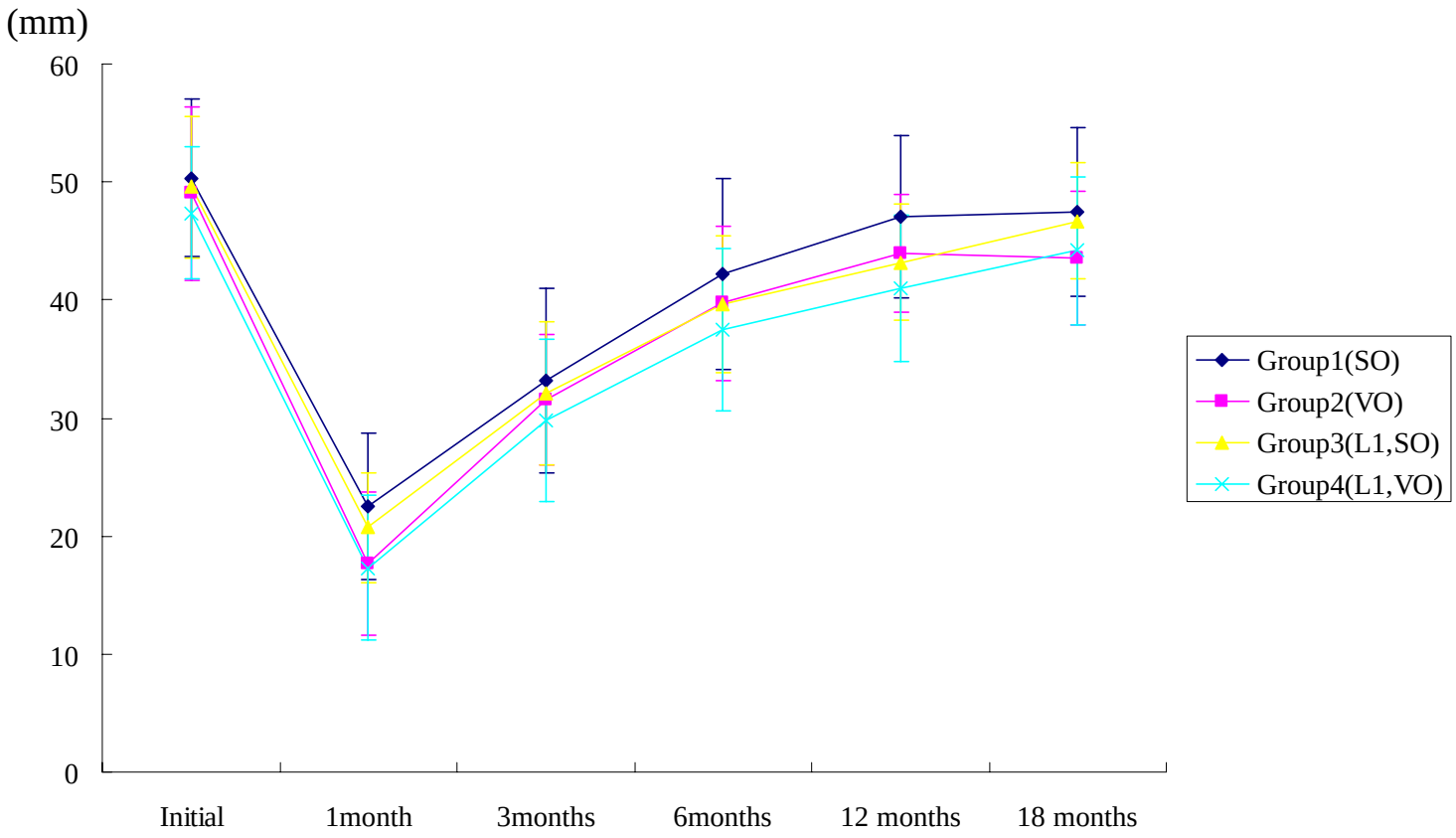
(mm)
60
50
40
30
20
10
0
Initial
1month
3months
6months
12 months
18 months
Group1(SO)
Group2(VO)
Group3(L1,SO)
Group4(L1,VO)

Fig.1

	Initial		1month		3months		6months		12 months		18 months	
	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD	Average	SD
Group1(SO)	50.4	6.0	22.5	4.7	33.2	6.1	42.2	5.8	47.1	4.9	47.5	4.9
Group2(VO)	49.1	5.6	17.6	6.1	31.5	6.9	39.8	6.9	43.9	6.2	43.5	6.3
Group3(L1,SO)	49.6	6.7	20.7	6.2	32.1	7.9	39.6	8.1	43.2	6.9	46.7	7.1
Group4(L1,VO)	47.4	7.4	17.3	6.0	29.8	5.6	37.5	6.5	41.0	5.0	44.2	5.7

Table 1.

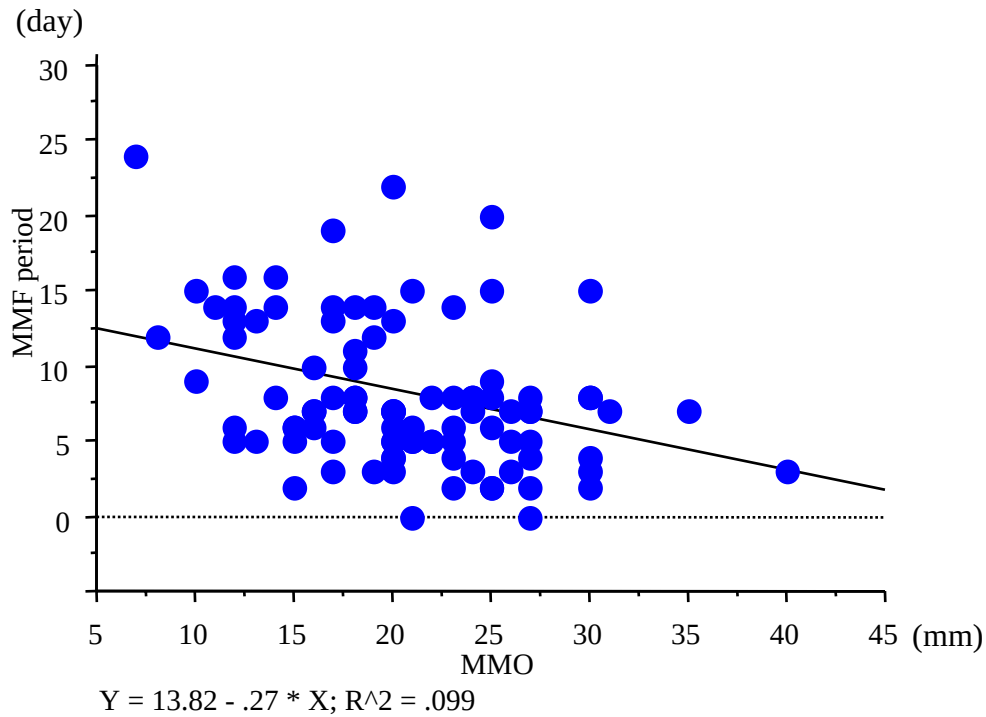
(day)
30
25
20
15
10
5
0
MMF period
5
10
15
20
25
30
35
40
45
(mm)
MMO
Y = 13.82 - .27 * X; R^2 = .099

Fig.2

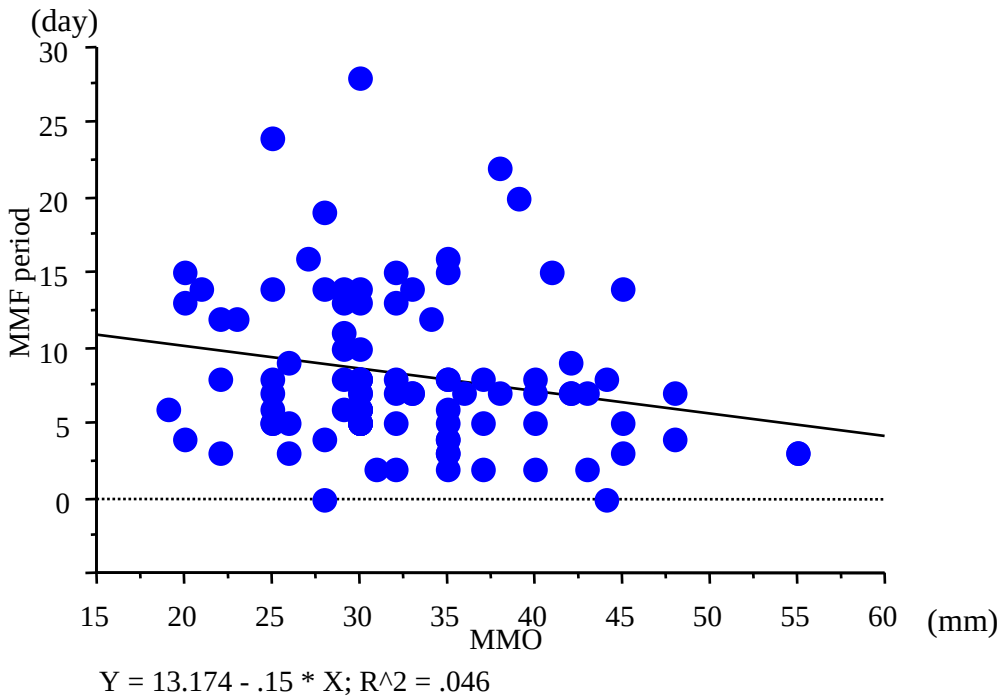
(day)
30
25
20
15
10
5
0
MMF period
15
20
25
30
35
40
45
50
55
60
(mm)
MMO
Y = 13.174 - .15 * X; R^2 = .046

Fig.3

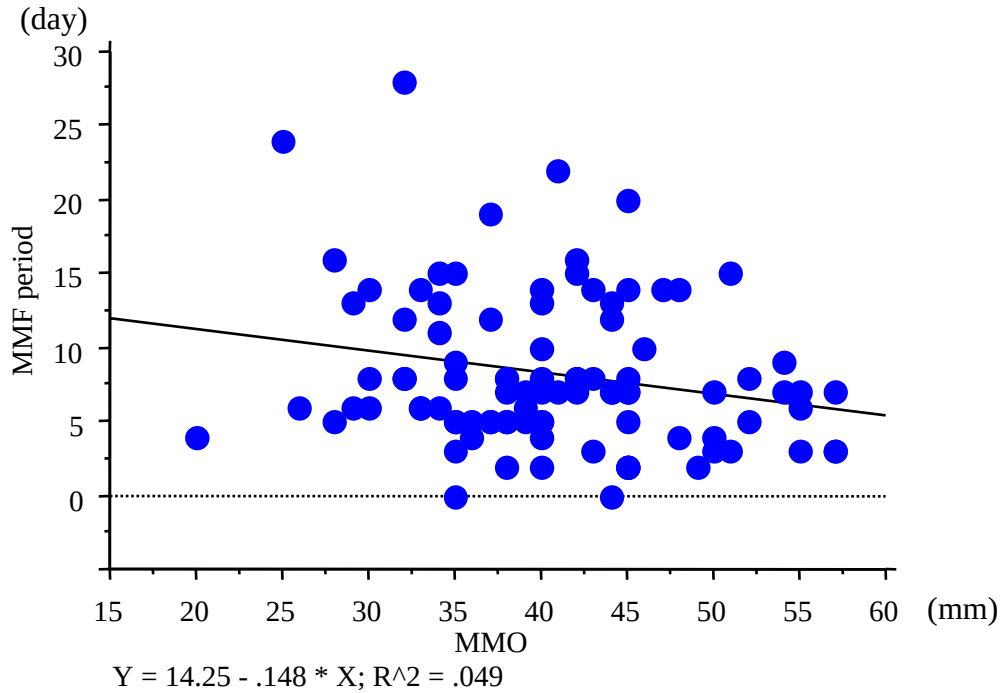
(day)
30
25
20
15
10
5
0
MMF period
15
20
25
30
35
40
45
50
55
60
(mm)
MMO
Y = 14.25 - .148 * X; R^2 = .049

Fig.4

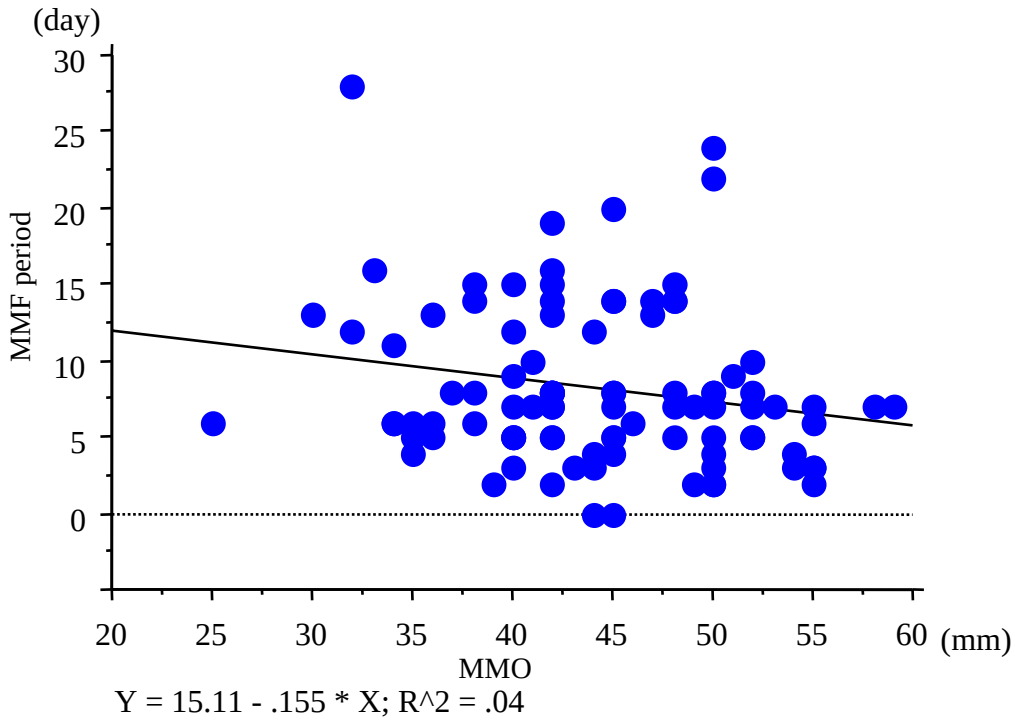
(day)
30
25
20
15
10
5
0
MMF period
20
25
30
35
40
45
50
55
60
(mm)
MMO
Y = 15.11 - .155 * X; R^2 = .04

Fig.5

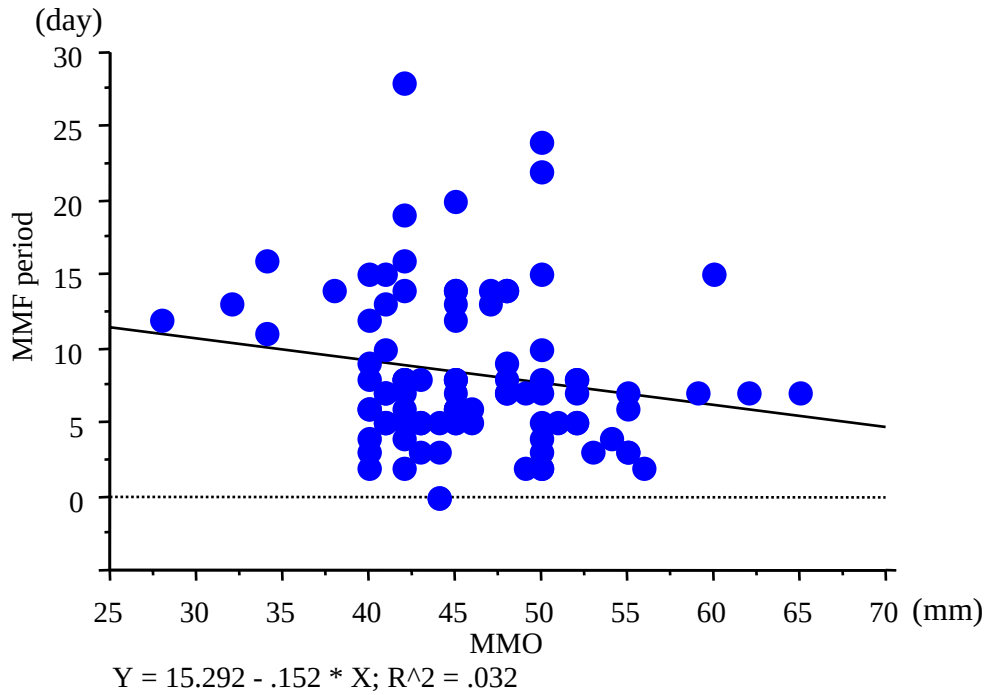
(day)
30
25
20
15
10
5
0
MMF period
25
30
35
40
45
50
55
60
65
70
(mm)
MMO
Y = 15.292 - .152 * X; R^2 = .032

Fig.6