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Effect of the additional installation of implants in the posterior region on the prognosis of treatment in the edentulous mandibular jaw

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Abstract: The aim of this study was to elucidate the effect of the additional installation of implants in the posterior region on the prognosis of treatment in the edentulous mandibular jaw. Fifteen patients who had received implants (Brånemark system, Nobel Biocare, Goteborg, Sweden) in the edentulous mandible and completed a 1-year follow-up after the fitting of implant-anchored fixed prostheses were selected. In seven patients (Group A), four or five implants were installed between the mental foramina, and in eight patients (Group P), one or two implants, one on each side, were installed in the posterior regions in addition to the implants between the foramina. All implants of both groups achieved osseointegration. In Group A, there was no implant loss after loading. Six implants were lost in five patients of Group P within 1 year after loading. All of them were located in the posterior region. To elucidate whether or not the failure rate of the implants in the posterior region of Group P after loading was especially high, the failures were also compared with 89 implants, which were installed in the posterior region of the mandibles to support implant-anchored fixed partial prosthesis, during the same period (Group C). The cumulative survival rate of the implants of Group P was 60%, while that of the implants of Group C was 100% ($P<0.001$). When the survival rates of posterior implants with the same length of the two groups were compared, there were significant differences for the 7- and 10-mm-length implants only. These data demonstrate that the posterior implants in Group P are at greater risk. Deformation of the mandible due to jaw movement was thought to be the most likely cause of the implant loss. Therefore, when such modified treatment is chosen, it should be performed with meticulous attention.

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Brånemark established the concept of osseointegration in the 1960s, and started clinical applications of osseointegrated implants (Brånemark et al. 1977). In the beginning, osseointegrated implants were applied to full edentulous jaws. In mandibular jaws, he recommended that only four to six implants be installed between the mental foramina to support an implant-anchored fixed full prosthesis (Fig. 1). The survival rate of implants using this method exceeds 95% even after 10 years (Henry et al. 1995; Lindquist et al. 1996). In addition, the survival rate of the superstructure is almost 100%. However, one identified problem is that the cantilever of the superstructure can be extended only to the second premolar or the center of the first molar. Some patients prefer to eat using a distal occlusion due to their eating habits

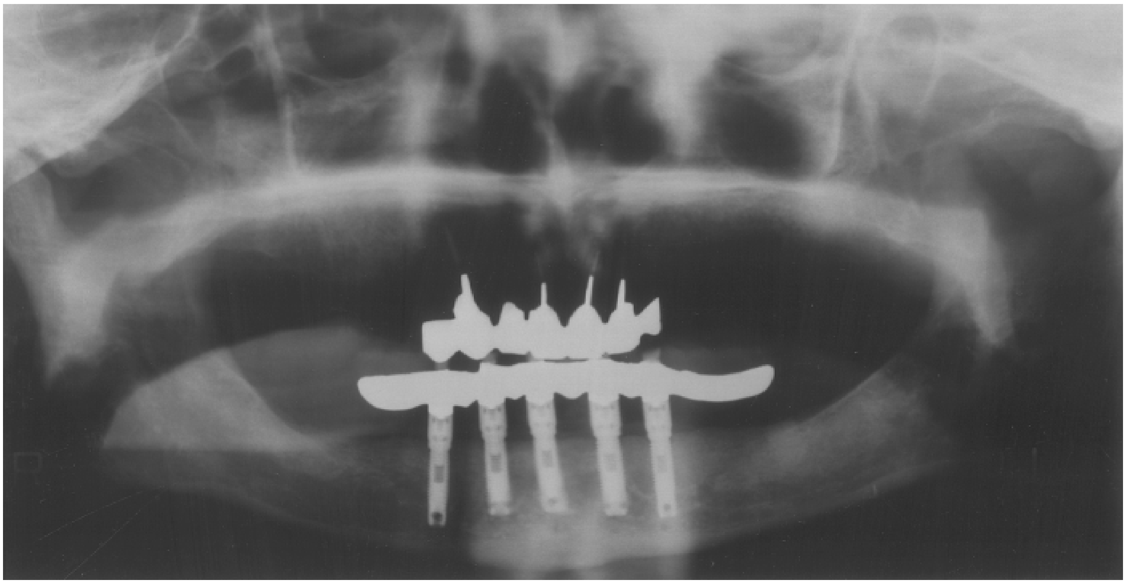

Fig. 1. Radiograph of a patient with a fully edentulous mandibular jaw treated using the method recommended by Brånemark. Five implants are installed between the mental foramina to support an implant-anchored fixed full prosthesis.

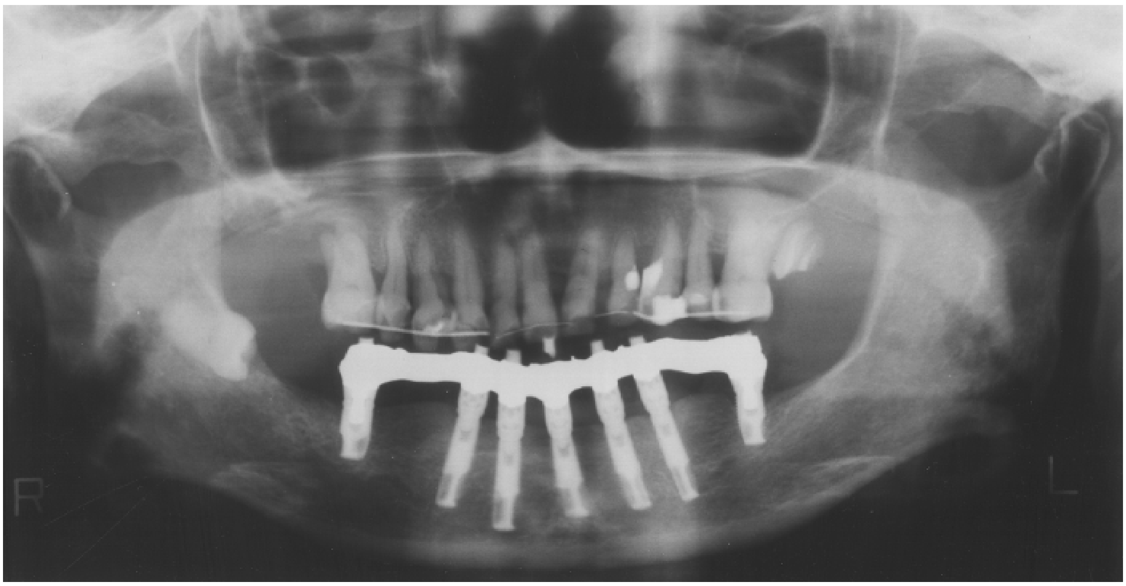

Fig. 2. Radiograph of a patient with a fully edentulous mandibular jaw treated by Komiyama's modification. One additional implant was installed in each side of the posterior region of the mental foramen in addition to the five implants between the mental foramina to support an implant-anchored fixed full prosthesis.

(Komiyama 1996). In order to solve this problem, Komiyama (1996) recommended that one more implant be installed additionally on each side posterior to the mental foramen, when enough bone is available for implant installation (Fig. 2). He started the clinical application of this modification from 1985 and reported that the previous biological, mechanical and functional problems were not experienced in any more than 90 fully edentulous mandibles. According to Komiyama (1996), the following improvements were reported: (1) improvement of chewing efficiency due to the expansion of the occlusal area, (2) avoidance of the fracture of components and overloading of the bone surrounding the implants due to the widely dispersed arrangement of implants, and (3) improved satisfaction with the restoration and the recovery of self-confidence as psychological effects. Although Komiyama (1996) reported excellent results for the modification, there have been no replica studies performed by other facilities on the modification.

In this study, the effect of the additional installation of implants in the posterior region in the fully edentulous mandibular jaw was investigated.

Material and methods

Overall, 28 patients with fully edentulous mandibles were treated, using the Brånemark implant system (Nobel Biocare, Gotebörg, Sweden) since 1992. Since eight patients were treated with the immediate loading method and five patients had less than 1-year follow-up time after the placement of the prostheses, they were excluded from this study. The present study was carried out on the remaining 15 patients who received treatment according to the manual of the Brånemark system (Adell et al. 1985).

Table 1 shows a summary of the patients in this study. For Group A, in all but one patient, five implants were installed between the mental foramina. The mean age of the patients at implant installation was 60.4 years. For Group P, in all but one patient, two implants, one on each side, were installed in the posterior regions of the mental foramen in addition to the implants between the mental foramina. The mean age at implant installation was 57.0 years. All patients were followed for at least 1 year after the fitting of their implant-anchored fixed full prostheses.

The patients were recalled 1, 2 and 4 weeks after the placement of the prostheses, and approximately every 2 months up to 1 year, and approximately every 6 months thereafter. The prostheses were removed every recall visit and the condition of the prostheses and gold-retaining screws, implant mobility, and adjacent mucosa were all evaluated. Patient symptoms were also recorded and used, along with the clinical and radiographic signs, to diagnose problems. Additional treatment was then provided as needed. The success criteria proposed by Smith & Zarb (1989) for the evaluation of osseointegrated dental implants were used to evaluate individual implants at each recall appointment.

The difference in failure rates between these two groups was examined statistically. To elucidate whether or not the failure rate of the implants after loading in the posterior regions of Group P was especially high, the cumulative implant survival rate was also compared with that of 89 implants (Group C) installed in the posterior regions to support implant-anchored fixed partial prostheses during the same period at our clinic.

Table 2 shows a summary of the 89 implants in 36 patients. Twenty patients were male and 16 were female, and the mean age of the patients at implant installation was 54.6 years. Forty-nine implants were installed in male and 40 implants in female.

Data were analyzed with the 'Stat View 5.0' program (Abacuus Concepts Inc., Berkeley, CA, USA). For the patient implant failure rate, the χ^2 test for independence was performed. In cases where the number of specimens for the test is less than 5, Fisher's exact probability test was used for accuracy. The cumulative implant survival rates were calculated with a Kaplan–Meier life table analysis and were compared using the log-rank test. Statistical significance was denoted when $P<0.05$.

Results

All implants of both groups achieved osseointegration and clinically showed no mobility until the fitting of their prostheses.

In Group A, no patients had implant loss after loading, while implant loss occurred in five out of eight patients in Group P ($P<0.05$, Table 1). Six implants were lost in five patients of Group P. All implants were located in the posterior region of the mental foramen and showed a slight mobility at recall and were easily removed by counter-rotation within 2 weeks after the detection of the mobility. The day the mobility of the implant was detected was recorded as the day of failure of the implant. However, the implants did not show marginal bone loss or a surrounding radiolucent line. Clinically, there were no other visual inflammatory signs or symptoms. In the five

***Table 1*. Patients, number, position and length of implants, maxillary dentition and follow-up time.**

Patient no.	Age	Sex	No. of implants	Implant length (mm)								Maxillary dentition	Time after superstructure (years months)
				Posterior region of right side	Anterior region					Posterior region of left side			
A1	68	M	5		15	15	15	15	15			Partial denture	8y 6m
A2	66	M	5		13	13	13	13	15			Partial denture	7y 6m
A3	25	F	5		13	13	13	13	13			Partial denture	7 y
A4	75	F	5		13	13	13	13	13			Full denture	6y
A5	65	F	5		15	15	15	15	15			Full denture	4y 1m
A6	57	F	5		15	15	15	13	15			Full denture	3y 1m
A7	67	M	5		13	13	13	13				Full denture	2y 6m
P1	61	F	7	10	18	18	18	18	18		13	Full denture	5y 6m
P2	43	M	7	13	20	20	20	20	20		15	Natural teeth + implant	5y
P3	54	M	7	10	18	18	18	18	18		10*(3)	Partial denture	4y 6m
P4	76	M	7	13	18	18	18	18	18		15	Full denture	3y 4m
P5	35	M	6	<u>7</u>*(10)	13	15	15	15	13			Natural teeth	2y 11 m
P6	60	F	8	<u>7</u>	15	15	15	15	15	15	7*(11)	Full denture	2y 6m
P7	61	M	8	<u>7</u>	15	13	13	13	13	15	<u>7</u>*(6)	Full denture	2y 6m
P8	66	F	7	<u>10</u>*(5)	18	18	18	18	18		<u>10</u>*(7)	Natural teeth	2y

*failed implant after loading.

_: Wide implant of 5 mm in diameter.

( ): Number of months from the superstructure fitting to the implant loss.

Partial denture means removal partial denture.

Table 2. **Summary of 89 implants installed in the posterior region to support implant-anchored fixed partial prostheses during the same period at our clinic.**

Length of implant (mm)	Number of implants			Time from loading		
	3.75 mm Ø	5.0 mm Ø	Total	(years months)		
7	3	10	13	3y 8m	±	1y 3m
8.5	0	3	3	3y 7m	±	8 m
10	11	12	23	4y	±	1y 5m
11.5	0	6	6	3y 5m	±	10 m
13	20	8	28	3y 11m	±	1y 6m
15	15	0	15	4y 11m	±	1y 1m
18	1	0	1	3y 3m		

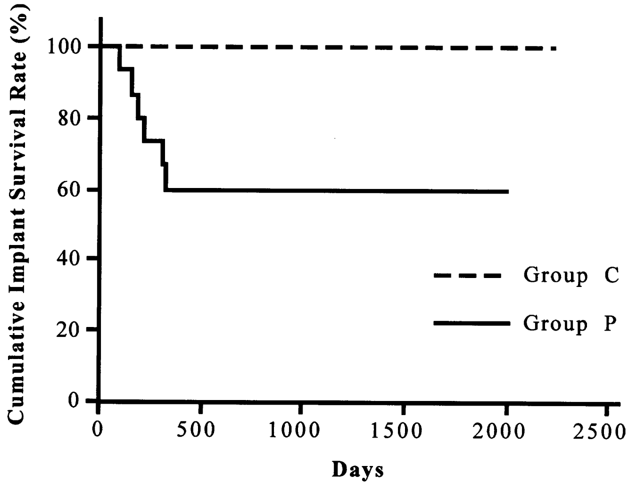

Fig. 3. Cumulative survival rate of the implants after loading which were placed in the posterior regions of the mandibles. Log-rank test shows the significant difference in cumulative implant survival rates between Groups C and P ($P < 0.001$).

Table 3. **Cumulative implant survival rates of different length implants placed in the posterior region of the mandibular jaws after loading.**

Length of implant (mm)	Cumulative implant survival rate (%)	
	Group C	Group P
7	100.0	40.0*
10	100.0	40.0**
13	100.0	100.0
15	100.0	100.0

*P<0.01,
**P<0.001 as compared with the rate of the same length implant of Group C.

patients with implant loss, the cantilevers of the superstructures were cut at a point 20 mm from the distal implant located in the anterior region of the mental foramen, so that the prosthetic survival rate was 100%.

To elucidate whether or not the failure rate of the posterior implants after loading in Group P was especially high, the cumulative implant survival rate of Group P was also compared with that of 89 implants (Group C) installed in the posterior regions to support implant-anchored fixed partial prostheses during the same period at our clinic. The overall cumulative survival rate of posterior implants of Group P was 60.0% and that of Group C was 100% (P<0.001, Fig. 3). When the cumulative implant survival rates of the posterior implants of Group P were compared to those of Group C with the same length, there were significant differences in 7- and 10-mm implants and no differences in the implants longer than 10 mm between the two groups (Table 3).

Regarding the maxillary dentition of five patients of Group P, two of the five patients with implant loss had full denture as maxillary dentition, while one out of three patients without implant loss had natural teeth and implant-anchored fixed partial prosthesis (Table 1).

With respect to the periods from the fitting of the superstructures to the detection of implant loss of Group P, three implants were detected to have lost osseointegration within 6 months, and the remainder were detected as a failure within 1 year after loading (Table 1).

With regard to failure after loading of the implants with different diameters located in the posterior regions in Group P, two out of nine and four out of six implants were lost with 3.75 and 5.00 mm diameters respectively.

Discussion

The present study demonstrates that the additional installation of implants in the posterior region of the mandible worsens the prognosis of these implants. Three factors might be responsible for this implant loss: (1) deterioration of the accuracy of the superstructure due to its expanded length, (2) location of the most distal implant in the posterior region exerting the highest load, and (3) deformation of the mandible due to jaw movements.

Stress is concentrated in the most distal implant in the posterior region because the deformation of the mandible in the molar region is much larger than that in the canine and premolar regions (Korioth & Hannam 1994; Abdel-Latif 2000). Also, reason (2) brings about a concentration of the load on the most distal implant in the posterior region and would be a candidate cause for the implant loss. Stress due to inaccuracy of the framework is not always concentrated in the most distal implant.

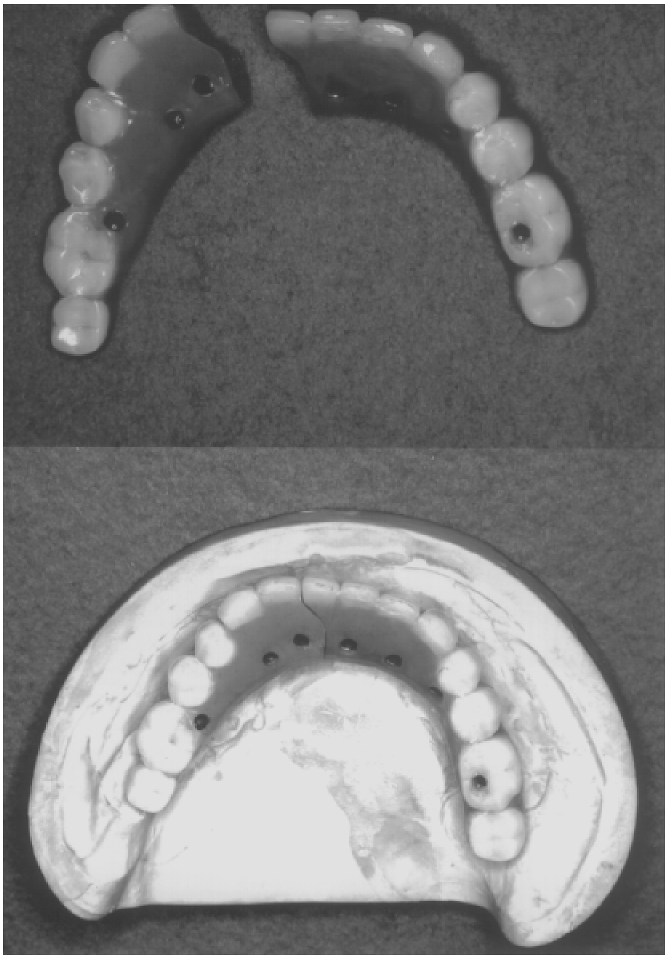

Fig. 4. Implant-anchored fixed full prosthesis for an edentulous mandibular jaw divided into two pieces, meaning two fixed partial prostheses. One is supported by three implants and the other is supported by four implants. Since the most distal contralateral implants are separated, the stress to the implants caused by the deformation of the mandible might be reduced.

Therefore, this factor is less probable as the cause of the implant loss.

Although one or two implants are often installed in the posterior regions in addition to the implants in anterior regions in fully edentulous maxilla to support the implant-anchored fixed full prostheses, systematic loss of the most distal implant has never been reported and was not observed in our clinic. Thus, the second reason might be excluded and the most possible cause is reason (3). The result that the kind of antagonistic teeth did not affect implant loss demonstrates that occlusal force would not be related to implant loss. This also supports reason (3) as the cause of the implant loss.

With regard to mandibular deformation, Chen et al. (2000) measured the change in width between mandibular first molars as the deformation of the mandible using natural teeth. The mandibular arch width narrowed during mouth opening and the changes in width ranged from 20 to 437 μm. Abdel-Latif et al. (2000) measured the change in length between implants in the right and left premolar regions (medial convergence) during jaw movement. Medial convergence of up to 41 μm was observed. Hobkirk & Schwab (1991) also measured relative movement and force transmission between osseointegrated implants in the premolar regions of the fully edentulous mandible. Although there were

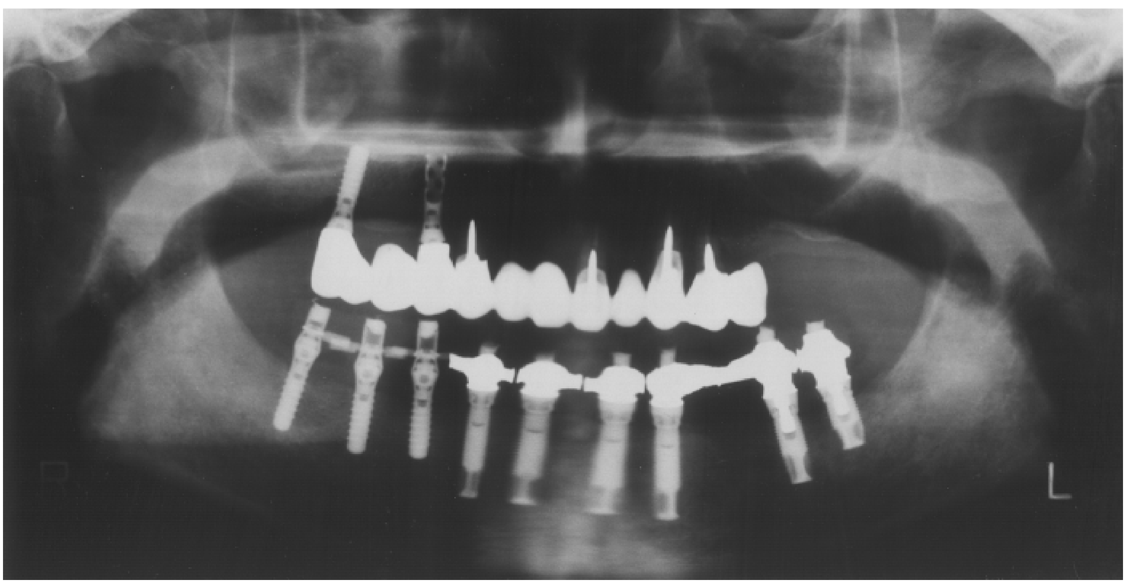

Fig. 5. Radiograph of a patient with multiple implants in the posterior region of the mental foramen. Since the multiple implants in the posterior region could support a larger load, they might reduce the deformation of the mandible.

wide variations from subject to subject, they reported deformations of up to 420 μm and a force transmission of up to 16 N during jaw movement, and concluded that the deformations might be potentially harmful to the interfaces between the implants and bone and the various components of the superstructure. Data from our group showed the distance between the implants in the right and left molar regions to be shortened by 91.1 μm, while the distance between the distal implants in the interforaminal area was shortened by only 7.1 μm during mouth opening (Ikeda et al. 1998, 1999). During protrusion and lateral excursions, the change of distance between the implants in the posterior region were 172.6 and 61.0 μm, and the distance between the distal implants in the interforaminal area were 9.7 μm and 6.7 μm, respectively. Although our data on the premolar region were similar to those of Abdel-Latif et al., our data showed that the change in distance between implants in the molar regions was 9–18 times greater than that of the distance between the implants in the premolar regions during various jaw movements. Abdel-Latif, et al. also reported that not only medial convergence but also corporal rotation and dorsoventral shear jaw deformations occur concurrently during mouth opening and lateral excursions. Moreover, there is an interesting case report on mandibular deformation and osseointegrated implants (De Oliveira & Emtiaz 2000). De Oliveira & Emtiaz reported that there was a possible correlation between the mandibular deformation and the discomfort experienced by a patient rehabilitated with implant-supported restoration for the mandibular arch during function and that recovery from the pain and symptoms was achieved only after splitting the prosthesis into three sections. Thus, deformation of the mandible due to jaw movement was thought to be the most likely cause of implant loss in the posterior region.

It is still unclear why Komiyama reported such a good prognosis in the modified method. Our failure rate of implants after loading in the posterior region supporting implant-anchored fixed partial prostheses corresponds to the range of the failure rates published previously (Olsson et al. 1995; Esposito et al. 1998; Lekholm et al. 1999; Bahat 2000). This indirectly supports the fact that our techniques of surgery and fabrication of prostheses are appropriate. The good prognosis of the modification by Komiyama might be based on a delicate balance between the deformation of the mandible and the stiffness of the superstructure. We do not recommend the additional installation of implants in the molar region to support the implant-anchored fixed full prostheses in the edentulous mandibular jaw. When the modification is applied, we recommend the installation of an implant that is longer than 10 mm.

In order to chew with the second molars without implant loss, we offer two suggestions. One is an implant-anchored fixed prosthesis divided into two pieces, meaning two fixed partial prostheses (Fig. 4). Since the most distal contralateral implants are separated in this case, the stress to the implants caused by the deformation of the mandible is reduced. The other is the installation of multiple implants into the posterior region of the mental foramen (Fig. 5). Since multiple implants in the posterior region could support a larger load, they would withstand the force from the mandibular deformation and might also be able to reduce the deformation. The disadvantage of this method would be the higher cost. However, when two implants are installed into the molar region on each side, three implants would be enough for the interforaminal area. Although our cases of the two modifications are still few in number and follow-up durations are still short, all cases have been successful to date and these methods might be able to solve the present problem.

In conclusion, the failure rate of implants after loading in the posterior region of the mental foramen, in addition to implants in the interforamina area of the fully edentulous mandible, was significantly elevated. Deformation of the mandible due to jaw movement was thought to be the most likely cause for this implant loss. Therefore, when such a modified treatment is chosen, it should be performed with meticulous attention.

Résumé

Le but de cette étude a été d'examiner l'effet de l'installation supplémentaire d'implants dans la région postérieure sur le pronostic de traitement au niveau des mandibules édentées. Quinze patients qui avaient reçu des implants *ad modum* Brånemark dans la mandibule édentée et achevé un suivi d'une année après l'ancrage de prothèses fixes ont été sélectionnés. Chez sept patients (groupe A) quatre ou cinq implants ont été placés entre les trous mentonniers, et chez huit patients (groupe P), un ou deux implants, un de chaque côté, ont été placés dans les régions postérieures en plus des implants entre les trous mentonniers. Tous les implants se sont ostéoïntégrés. Dans le groupe A, il n'y avait aucune perte d'implants après la mise en charge. Six implants ont été perdus chez cinq patients dans le groupe P durant la première année de mise en charge. Tous étaient localisés dans la région postérieure. Pour élucider si le taux d'échec des implants dans la région postérieure du groupe P après la mise en charge était spécialement élevé, les échecs ont également été comparés avec 89 implants qui avaient été installés dans la région postérieure de mandibules afin de supporter des prothèses partielles fixées durant la même période (groupe C). Le taux de survie cumulatif des implants du groupe P était de 60% tandis que pour les implants du groupe C il était de 100% ($p<0,001$). Lorsque les taux de survie des implants postérieurs avec la même longueur dans les deux groupes étaient comparés, il n'y avait des différences significatives que pour les implants de 7 et 10 m de long. Ces données démontrent que les implants postérieurs dans le groupe P représentent un risque important. La déformation de la mandibule düe aux mouvements de la mâchoire a été considérée comme cause la plus vraisemblable de la perte implantaire. Lorsqu'un tel traitement modifié est choisi, il devrait donc être effectué avec une attention toute particulière.

Zusammenfassung

Das Ziel dieser Arbeit war es, den Einfluss von zusätzlichen in der posterioren Region gesetzten Implantaten auf die Prognose bei der Behandlung von zahnlosen Unterkiefern zu untersuchen. Man wählte 15 Patienten aus, die im zahnlosen Unterkiefer Implantate (Brånemark-System, Nobel Biocare, Göteborg, Sweden) erhalten haben, und die nach deren Versorgung im ersten Jahresrecall erschienen sind. Bei sieben Patienten (Gruppe A) hatte man vier oder fünf Implantate zwischen die beiden Foramen mentale gesetzt, und bei acht Patienten (Gruppe P) hatte man zusätzlich zu den interforaminal gelegenen Implantaten noch beidseits je ein bis zwei Implantate in der posterioren Region gesetzt. Alle Implantate der beiden Gruppen osseointegrierten erfolgreich. In der Gruppe A kam es zu keinem Implantatverlust nach der Belastung. In der Gruppe P gingen innerhalb des einen Jahres mit funktioneller Belastung bei 5 Patienten sechs Implantate verloren. Sie lagen alle in der posterioren Region. Um herauszufinden, ob die Misserfolgsrate nach der Belastung der Implantaten in der posterioren Region der Gruppe P speziell hoch war oder nicht, wurde sie mit derjenigen von 89 Implantaten (Gruppe C) verglichen, die während derselben Zeit in der posterioren Region des Unterkiefers zur Befestigung von implantatgetragenen Brücken gesetzt worden waren. Die kumulative Überlebensrate der Implantate in der Gruppe P war 60%, während dem diejenige der Implantate in der Gruppe C 100% war (p<0.001). Verglich man bei diesen beiden Gruppen die Überlebensrate von posterioren Implantaten derselben Länge, fand man einzig für die 7 und 10 mm langen Implantate signifikante Unterschiede. Diese Resultate zeigen, dass die posterioren Implantate der Gruppe P einem grösseren Risiko unterworfen sind. Die Erklärung für den Implantatverlust lag wahrscheindlich in der Unterkieferverformung während den Kieferbewegungen. Daher sollte man bei der Anwendung solch modifizierter Behandlungskonzepte äusserste Vorsicht walten lassen. Der Einfluss von zusätzlichen Implantaten in der posterioren Region bei der Behandlung von zahnlosen Unterkiefern.

Resumen

La intención de este estudio fue dilucidar el efecto de la instalación adicional de implantes en la región posterior en el pronóstico del tratamiento en la mandíbula edéntula. Se seleccionaron quince pacientes que habían recibido implantes (Sistema Brånemark, Nobel Biocare, Goteborg, Suecia) en la mandíbula edéntula y completaron un año de seguimiento tras el ajuste de de prótesis fija anclada a los implantes. Se instalaron cuatro o cinco implantes en siete pacientes (Grupo A) entre los forámenes mentonianos, y en ocho pacientes (Grupo P) se instalaron uno o dos implantes en las regiones posteriores como adición a los implantes entre los forámenes. Todos los implantes de ambos grupos lograron la osteointegración. En el Grupo A no hubo pérdida de implantes tras la carga. Se perdieron seis implantes en 5 pacientes del Grupo P dentro del año tras la carga. Todos ellos estaban localizados en la región posterior. Para dilucidar si el índice de fracasos de los implantes en la región posterior del grupo P tras la carga fue especialmente alto, se compararon los fracasos con 89 implantes, que fueron instalados en la región posterior de la mandíbula para soportar prótesis parciales fijas ancladas en implantes, durante el mismo periodo (Grupo P). El índice acumulativo de supervivencia de los implantes del Grupo P fue del 60%, mientras que el de los implantes del Grupo C fue del 100% (p<0.001). Cuando se compararon los índices de supervivencia de los implantes posteriores con la misma longitud de los dos grupos, hubo diferencias significativas solo para los implantes de 7 y 10 mm de longitud. Estos datos demuestran que los implantes posteriores en el Grupo P tienen un riesgo mayor. Se pensó que la deformación de la mandíbula debida al movimiento era la causa mas probable de pérdida de los implantes. Por lo tanto, cuando se elige dicho tratamiento modificado, debe ser llevado a cabo con una atención meticulosa.

要旨

本研究では、下顎無歯顎患者の治療において、オトガイ孔間に加えて臼歯部へのインプラントの追加埋入が予後に及ぼす影響を検討した。

下顎無歯顎にインプラント(Branemark システム, Nobel Biocare, ｲｴﾃﾎﾞﾘ、ｽｴｰﾃﾞﾝ) を埋入し、インプラント支持の固定性補撤物装着後１年以上追跡評価を行った１５名の患者を対象とした。７名の患者（Ａ群）ではオトガイ孔間に４あるいは５本のインプラントを埋入し、８名の患者（Ｐ群）ではオトガイ孔間のインプラントに加えて、片側の臼歯部に１あるいは２本のインプラントを追加埋入した。

両群のインプラントは全て骨結合を獲得した。Ａ群では荷重後にインプラントの喪失はなかった。Ｐ群の患者５名において、荷重後１年以内に６本のインプラントが脱落した。脱落したインプラントは全て臼歯部に埋入されたものであった。Ｐ群における臼歯部インプラントの荷重後の失敗率が特異的に高いかどうかを評価するために、同じ期間中に、部分欠損用の固定性補綴物を支持するために下顎臼歯部に埋入されたインプラント８９本（Ｃ群）の失敗率と比較した。臼歯部に埋入されたＰ群インプラントの累積生存率は６０％であり、Ｃ群インプラントは１００％であった（ｐ＜０．００１)。両群の同じ長さのインプラントの生存率を比較したところ、長径７ｍｍと１０ｍｍのインプラントに有意差がみられた。

これらのデータはＰ群の臼歯部に埋入されたインプラントは、失敗のリスクが特に高い事を示唆している。顎運動に伴う下顎の変形が、このインプラント喪失の原因であると考えられる。従って、このような治療法を選択する場合には、十分な注意が必要である。

キーワード：下顎無歯顎、変形、失敗、歪

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