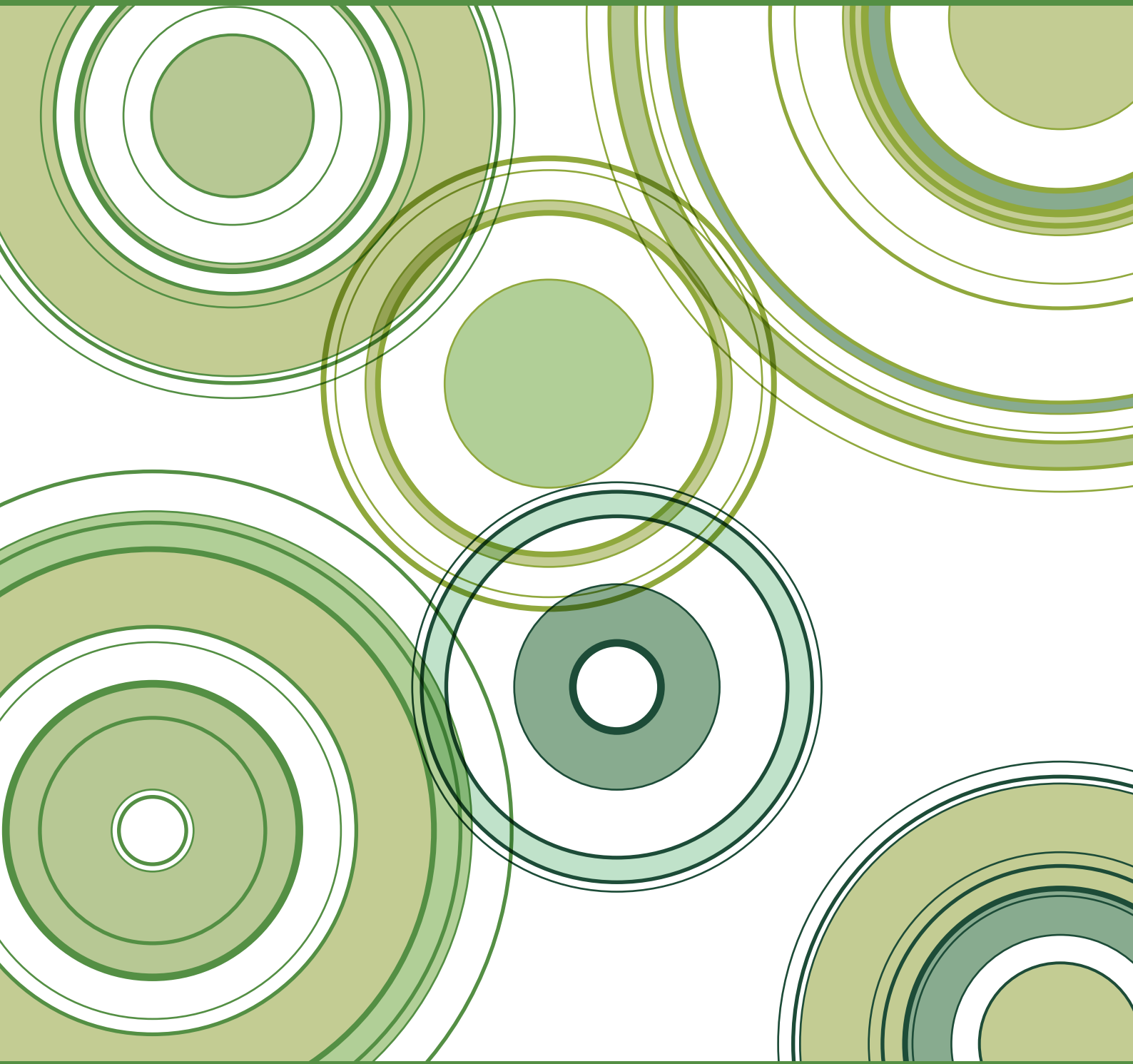
九州歯科學會雑誌

The Journal of The Kyushu Dental Society

Vol.73 | No.1 | November 2019

第73巻　第1号　令和元年11月　ONLINE ISSN：1880-8719　PRINT ISSN：0368-6833



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九州歯科学会雑誌

第73巻　第１号

（令和元年11月）

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原著

The Journal of the Kyushu Dental Society

Vol. 73 No. 1

Original Work

九州歯会誌　73(1)：1～10，2019.

Association between dental status and high-risk group of cardiovascular disease in Japanese factory workers aged 55 years and older: A cross-sectional study

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Received August 9 2019
Accepted November 7 2019

Abstract

Increased blood pressure in middle-aged individuals (up to 55 years old) is associated with a higher remaining lifetime risk of cardiovascular disease (CVD). Previous studies suggested that work-related strain was associated with increased risk of CVD events in hypertensive Japanese workers aged 40–65 years. On the other hand, dental caries, periodontal diseases, and tooth loss are associated with hypertension. The aim of our study was to evaluate the association between high-risk group of cardiovascular disease and dental status in Japanese manufacturing workers aged 55 years and older.

This cross-sectional study evaluated the association between high-risk group of CVD and dental status in Japanese manufacturing workers aged 55 years and older, after adjusting for potential confounding factors via propensity score matching.

Individuals with high-risk group of CVD had significantly higher numbers of decayed teeth, lower numbers of filled teeth, and worse periodontal statuses than matched controls ($p < 0.05$). However, there was no significant difference between the high-risk group of CVD and non-high-risk group of CVD in numbers of present teeth.

Poor dental status may be one of the exacerbation factor of CVD in Japanese manufacturing workers aged 55 years and older.

Key words：Dental status / High blood pressure / Japanese factory workers / Propensity score

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Introduction

Japan is a hyper-aging society, with approximately 39% of the population older than 55 years of age in 2014 [1]. Increased blood pressure (BP) is associated with cardiovascular disease (CVD) [2]. Those in the 55 years and older age group with hypertension comprise a high-risk group for the onset of CVD [3]. In a cohort study on Japanese workers aged 40–65 years, work-related stress was reported to be associated with an increased risk of CVD events in hypertensive workers [4]. Furthermore, the prevalence of hypertension is known to be influenced by occupation type; manufacturing workers have the highest prevalence of hypertension, specifically among females [5]. Japanese manufacturing workers are thus at a high risk of hypertension, and BP is one of the exacerbating factors for the development of CVD in those aged 55 years and older.

On the other hand, dental caries, periodontal diseases, and tooth loss are associated with numerous cardiovascular risk factors [6-11]. However, few studies have evaluated the association between hypertension and oral diseases, such as caries and periodontal diseases, in individuals aged 55 years and older. The aim of the present cross-sectional study was therefore to evaluate the association between oral health status and hypertension in Japanese manufacturing workers aged 55 years and older. We hypothesized that individuals with hypertension would have more dental caries and periodontal diseases than those who are normotensive.

Material and methods

The current study was conducted in accordance with the World Medical Association Declaration of Helsinki and approved by the ethics committee of Kyushu Dental University, Kitakyushu, Japan (#15-22).

This cross-sectional study included factory workers aged 55 years and older who worked in the Japanese manufacturing industry. There were 997 manufacturing facilities in Kitakyushu, Japan, in 2016 [12]. We selected three factories for this study: TOTO Kifune, TOTO Kumasi, and Yasukawa. The surveyed companies were selected based on three conditions, as described as follows. First, these companies must have had full-time workers aged ≥ 55 years with the same occupation type. Second, one percent of the 997 manufacturing facilities were selected by network sampling. Third, the consent for survey participation was obtained after network sampling. The selected factories were different but belonged to the same type of manufacturing industry. Two dentists visited the recruited individuals to explain the aims of the study and to encourage participation. We recruited 200 individuals in total from TOTO Kifune, TOTO Kumasi, and Yasukawa Yahata in December 2013. Of these 200, the 167 individuals who agreed to participate signed an informed consent form before their clinical examinations. We excluded individuals who worked with acids (n = 4), such as hydrochloric acid, nitric acid, sulfuric acid, and sulfurous acid, as we could not properly assess oral statuses due to the dental erosion caused by these acids [13]. The participation selection flowchart is shown in Figure 1.

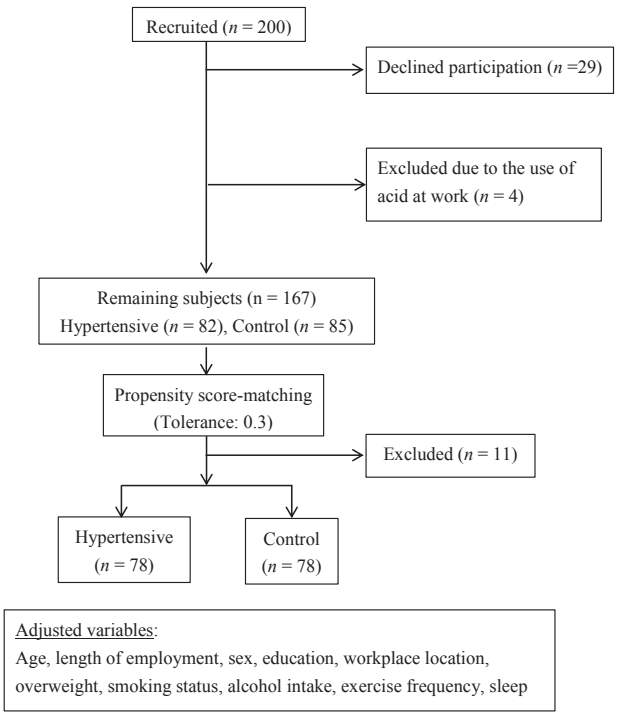

Figure 1.

The dentists administered a structured, written questionnaire to participants to obtain their demographic and health-related variables at the time of oral examination. Demographic variables included age, length of employment, sex (male or female), education (9–12, or > 12 years), and workplace location (T: TOTO Kifune factory; TK: TOTO Kusami factory; Y: Yasukawa Yahata factory). Health-related variables included smoking status (current smoker, past smoker, or never), alcohol intake per day (never, < 180 ml, 180–360 ml, or > 360 ml), exercise frequency of over 30 min (never, sometimes per week, or sometimes per month), sleep time (<6 h/d, 6–8 h/d, or ≥8 h/d), and work time (<6 h/d, 6–8 h/d, or ≥8 h/d). These variables and their cutoff points were determined using a standard questionnaire during individual health examinations [14]. The dentists checked the demographic and health-related data collected from the completed questionnaires to find missing or incorrect data. In cases of missing data, the dentists interviewed the participants to obtain the correct data.

The participants were then asked if they wished to withdraw from the study. Twenty-nine participants opted to withdraw at this point (Figure 1). The remaining participants then underwent a clinical examination. BP, weight, and height were measured by a trained undergraduate dental student from Kyushu Dental University, Kitakyushu, Japan. BP was measured in a room at 25 ° C (to mimic the effect of temperature change) using a calibrated electronic device (HEM-907; OMRON, Kyoto, Japan). The cuff was placed such that the lower edge was at least one inch above the elbow crease and the bladder was centered over the brachial artery. The arm was bared and supported with the antecubital fossa at the heart level. Two measurements were taken for the left arm, and the average was recorded. We also categorized overweight (BMI ≥ 25 kg/m^2) (yes or no) based on their weight and height.

Four trained dentists with over five years of clinical experience conducted the oral examinations. Two of the dentists were responsible for assessing the number of decayed teeth, filled teeth, and present teeth according to the World Health Organization criteria [15]. The decayed, missing, filled (DMF) index has been used for more than 70 years and is well established as the key measure of caries in dental epidemiology [16]. A tooth was diagnosed as sound when no evidence of restorative treatment or untreated dental caries was found. A tooth was considered decayed when the following were observed: cavitation of the enamel, dentinal involvement, or both; visible caries contiguous with a restoration; or total/partial coronal destruction resulting from disease progression. A tooth was considered filled when it contained one or more permanent restorations. When uncertainty regarding the diagnosis persisted, the tooth was classified as sound. The number of present teeth included not only normal teeth, but also teeth with only a root due to a crown. The other two dentists were responsible for the measurement of periodontal pockets using a manual periodontal probe. The probing depth (PD) [17-19] and clinical attachment loss (CAL) [20, 21] were measured at six sites per tooth (mesiobuccal, midbuccal, distobuccal, distolingual, mid-lingual, and mesiolingual). The PD was defined as the distance between the free gingival margin and the bottom of the periodontal pocket. The CAL was defined as the distance between the cementoenamel junction and the bottom of the periodontal pocket. We classified periodontitis according to the definitions developed by the Centers for Disease Control and Prevention periodontal disease surveillance workgroup [22]. We defined “severe periodontitis” as the presence of ≥ 2 interproximal sites with CAL ≥ 6 mm and ≥ 1 interproximal site with PD ≥ 5 mm (not on the same tooth). We defined “moderate periodontitis” as the presence of ≥ 2 interproximal sites with CAL ≥ 4 mm and ≥ 2 interproximal sites with PD ≥ 5 mm. We defined “no or mild periodontitis” as all other dental states, excluding severe and moderate periodontitis. We further categorized “no or mild periodontitis” as “no

periodontitis," and we categorized "moderate periodontitis" and "severe periodontitis" as "periodontitis." Before the start of the study, all assessors underwent training through use of a dentition model to ensure that subjective differences in probing pressures, probe insertion direction (approach from buccal side), probe insertion position (interproximal sites), and the position of participants during periodontal examinations were at a minimum.

Age, length of employment, decayed teeth, filled teeth, and present teeth were continuous variables. Education level was categorized as 9–12 years and >12 years of education. Work place location was designated as T (TOTO Kifune factory), TK (TOTO Kusami factory), and YY (Yasukawa Yahata factory). Body mass index (BMI), calculated as weight divided by height squared (kg/m^2), was categorized as obese and non-obese using the World Health Organization criteria for overweight (BMI $\geq$ 25 kg/m^2) [23]. Smoking status was categorized as current smoker, past smoker, and never. Alcohol intake per day was categorized as never, <180 ml, 180–360 ml, and >360 ml. Exercise frequency was categorized as never, sometimes per week, and sometimes per month, where an exercise session was defined as ≥30 min of aerobic exercise. Sleep time and work time were categorized as <6 h, 6–8 h, and >8 h. In addition, the participants were divided into two groups according to BP status: high-risk of CVD (high BP Stage 1: systolic BP 140–159 mmHg or diastolic BP 90–99 mmHg, high BP Stage 2: systolic BP ≥160 mmHg or diastolic BP ≥100 mmHg, and hypertensive crisis: systolic BP ≥180 mmHg or diastolic BP ≥110 mmHg) and non-high-risk of CVD (normal: systolic BP <120 mmHg and diastolic BP <80 mmHg and pre hypertension: systolic BP 120–139 mmHg or diastolic BP 80–89 mmHg) [24]. The previous study reported Individuals who maintained or decreased their BP to normal levels had the lowest remaining LTR for CVD, 22% to 41%, compared with individuals who had or developed hypertension by 55 years of age, 42% to 69%, suggesting a dose-response effect for the length of time at high BP levels. [3] Therefore, high-risk of CVD was identified based on the blood pressure results measured during the medical examination regardless of the presence or absence of antihypertensive drugs.

To create a control group comprising non-high-risk of CVD cases that mimicked the particular characteristics of the high-risk of CVD, we utilized the propensity score (PS) framework as described by Rosenbaum and Rubin [25] and implemented by Ho et al [26]. The PS model was estimated using logistic regression, adjusting for age, length of employment, sex, education, workplace location, overweight, smoking status, alcohol intake, exercise frequency, sleep time, and work time. High-risk of CVD cases were matched to non-high-risk of CVD cases using nearest-neighbor matching without replacement. The PS was matched using an algorithm derived from a 1:1 optimal match with a $\pm$ 0.3 tolerance and the replacement number.

After PS matching, the standardized difference was assessed to determine covariate balance, whereby an absolute standardized difference (AD) greater than 10% was considered to represent meaningful imbalance [27]. The AD performs better, in terms of bias reduction and variance, than other balance measures when compared across a wide range of sample sizes and covariate distributions [27].

Group differences in categorical variables were evaluated using the chi-square test or Fisher's exact test, as appropriate. The Kolmogorov-Smirnov test [28] was used to assess the equality of the distribution for continuous variables. All continuous variables had unequal distributions; thus, for all continuous variables, group differences were evaluated using the non-parametric Mann-Whitney U test.

P values < 0.05 were considered statistically significant. PS matching and all analyses were performed using the SPSS 24 statistical software package (SPSS Japan Inc., Tokyo, Japan).

Results

The characteristics of the high-risk of CVD and non-high-risk of CVD groups before and after PS matching are shown in Table 1. Of the 167 study participants, PS matching yielded 78 pairs (156 participants), and 11 individuals were excluded from analysis. The PS-matched hypertensive group consisted of 48 participants with high BP Stage 1, 23 with high BP Stage 2, and seven in hypertensive crisis. The PS-matched control group consisted of 19 normal and 59 pre-hypertensive participants. After PS matching, there were no statistically significant differences between the high-risk of CVD and matched control groups in terms of the background characteristics, including age, sex, length of employment, length of education, and behavioral risk indicators. Variables with an AD < 0.1 comprised workplace location, smoking status, and work time (Table 1, 2).

Table 1.

Variables	Full dataset				Propensity score–matched dataset			
	High-risk of CVD	Non-High-risk of CVD	*p* value	AD (%)	High-risk of CVD	Non-High-risk of CVD	*p* value	AD (%)
[I] Age, years	59.4	58.9	0.16	0.19	59.0	58.0	0.16	0.19
[I] Length of service, years	35.5	31.3	*0.04	0.36	40.0	39.0	0.09	0.29
[II] Sex, *n*								
Female	13	23	0.08	0.14	13	18	0.32	0.08
Male	69	62			65	60		
[III] Education, *n*								
9-12 years	80	82	0.61	0.15	77	75	0.55	0.13
> 12 years	2	3			1	3		
[II] Workplace location, *n*								
T	44	48	0.8	0.05	48	43	0.41	0.11
TK	15	17			16	14		
Y	23	20			14	21		
[II] Overweight (BMI ≥ 25 kg/m^2), *n*								
Yes	34	25	0.11	0.13	31	23	0.24	0.11
No	48	60			47	55		

*p < 0.05, [I] Mann Whitney U-test; [II] Chi-square test; [III] Fisher's exact test; CVD: cardiovascular disease; AD: Absolute standardized difference; BMI: body mass index; T: TOTO Kifune factory; TK: TOTO Kusami factory; Y: Yasukawa Yahata factory

Table 2.

Variables	Full dataset				Propensity score–matched dataset			
	High-risk of CVD	Non-High-risk of CVD	*p* value	AD (%)	High-risk of CVD	Non-High-risk of CVD	*p* value	AD (%)
[I] Smoking status, *n*								
Current smoker	29	35	0.78	0.06	28	32	0.75	0.06
Past smoker	25	24			23	23		
Never smoker	27	26			27	23		
[I] Alcohol intake per day, *n*								
Never	21	25	0.11	0.21	21	22	0.31	0.24
< 180 ml	16	28			16	25		
180-360 ml	33	25			30	24		
> 360 ml	12	7			11	7		
[I] Exercise frequency, *n*								
Never	42	37	0.47	0.12	40	34	0.34	0.12
per week	22	24			22	20		
per month	17	24			16	24		
[II] Sleep time per day, *n*								
< 6 hours	20	20	0.43	0.1	20	17	0.32	0.12
6-8 hours	54	61			51	58		
> 8 hours	8	4			7	3		
[II] Work time per day, *n*								
< 6 hours	3	4	0.56	0.08	3	2	0.53	0.09
6-8 hours	64	61			56	62		
> 8 hours	14	20			19	14		

*p < 0.05, [I] Chi-square test; [II] Fisher's exact test; HT: Hypertension; Non-HT: Non-Hypertension; AD: Absolute standardized difference

n logistic regression models adjusted for demographic and behavioral risk indicators, the median number of decayed teeth were zero with both group. But range of the median number of decayed teeth were from zero to 11 in high-risk of CVD group and from zero to 12 in Non-high-risk of CVD group. Therefore participants with high-risk of CVD tended to have significantly higher numbers of decayed teeth. The median number of filled teeth were 12 in high-risk of CVD group and was 14 in non-high-risk of CVD group. Participants with high-risk of CVD group tended to have significantly lower numbers of filled teeth than matched controls ($p < 0.05$; Table 3).

Table 3.

Dental status (number of teeth)	High-risk of CVD Median (min–max)	Non-high-risk of CVD group Median (min–max)	*p* value
Decayed teeth	0 (0–11)	0 (0–12)	*0.031
Filled teeth	12 (0–22)	14 (0–24)	*0.039
Present teeth	25 (0–28)	26(0–28)	0.903

*$p < 0.05$, Mann–Whitney U test

However, there was no significant group-based difference in the number of present teeth. In addition, participants with high-risk group of CVD tended to have significantly worse periodontal statuses than matched controls ($p < 0.05$; Table 4).

Table 4.

Severity of Periodontal disease	High-risk of CVD N, (%)	Non- high-risk of CVD N, (%)	*p* value
None	40 (51.3)	47(60.3)	*0.03
Mild	6 (7.7)	9 (11.5)	
Moderate	30 (38.5)	15 (19.2)	
Severe	2 (2.6)	7 (9.0)	

*$p < 0.05$, Fisher's exact test

Discussion

The current study found that Japanese factory workers aged 55 years and older with high-risk of CVD tended to have significantly higher numbers of decayed teeth and significantly worse periodontal statuses than non-high-risk of CVD individuals matched for common covariates associated with hypertension and dental diseases. Our study findings suggested that the 55 years and older age group with high-risk of CVD may pay less attention to oral health, as individuals in this group had higher numbers of decayed teeth and worse periodontal statuses. Both CVD and dental diseases constitute chronic non-communicable diseases (CNCDs) and are affected by CNCD-related lifestyle factors, particularly diet, physical activity, and tobacco and alcohol use [29, 30]. Patients aged 55 years and older with dental diseases may have more CNCD-related lifestyle factors, and a CNCD-related lifestyle can result in hypertension. We therefore adjusted for CNCD-related lifestyle factors in this study via PS matching. Although there were no significant group differences in any of the covariates after PS matching, there were still significant differences in the distribution of all covariates (based on the AD), with the exception of work location, smoking status, and work time.

High-risk of CVD and non-high-risk of CVD groups did not differ significantly in the number of present teeth in this study, which differs from the results of a previous study, in which individuals with fewer teeth tended to have higher systolic BP [31]. This may have been due to our inability to completely match the distribution of variables, including confounding factors such as diet. Diet is associated with hypertension [32], and oral status: periodontal inflammation [33], and root caries [34].

The current results suggest that high-risk of CVD tended to be associated with severe periodontal status, after adjusting for smoking status, which is consistent with the findings of a previous report [35]. Furthermore, the current results suggest that High-risk of CVD may be associated with dental status, after adjusting for the potential confounding variables via PS matching. The current study population differed from those in previous studies in terms of the age group (55 years and older), health status (healthy participants rather than hospital inpatients), and occupation (factory workers). Further studies are necessary to clearly determine whether dental status is a confounding factor in the association between hypertension and nutritional balance.

The current study has four main strengths. First, we

adjusted for confounding factors via PS matching. Second, after PS matching, we determined the AD and showed the valuables was adjusted on not, based on AD, in conjunction with the assessment of model fitting. The distribution of workplace location, smoking status, and work time were adequately comparable between the hypertensive and non-hypertensive groups. Third, the current results for hypertensive Japanese factory workers aged 55 years and older are largely consistent with previous reports. Fourth, our study findings may encourage medical staff to estimate the state of BP in the 55 years and older age group based on oral statuses.

The current study also has five main limitations. The first concerns the study's cross-sectional design, which cannot demonstrate causality between hypertension and the onset of dental diseases. The second limitation concerns generalizability, as we only recruited Japanese factory workers aged 55 years and older. The third limitation concerns the reliability of the oral data, given that we did not evaluate the diagnostic reproducibility between the two observers. The fourth limitation concerns the study's relatively small sample size. We acknowledge that many of the variables were not evenly distributed due to the relatively small sample size. Therefore, we were not able to construct an optimal control group based on the AD. Some items also that showed significant differences may not show significant differences. The fifth limitation concerns we cannot adjust the effect of antihypertensive medication nor the effect of severity of hypertension.

Conclusions

Japanese factory workers aged 55 years and older with high-risk of CVD have significantly higher numbers of decayed teeth and significantly worse periodontal statuses than matched controls. Thus, poor dental status may be one of the CVD risk factors in Japanese factory workers aged 55 years and older. The current study adjusted for age, sex, length of employment, length of education, workplace location, overweight, smoking status, alcohol intake, exercise frequency, sleep time, and work time. However, other factors may also be critical risk factors for CVD. Therefore, our findings could present a spurious association between hypertension and dental disease rather than any meaningful association due to the design of the study and the limited sample size. A prospective cohort study with more participants is necessary to evaluate the causality between the morbidity associated with oral diseases and the risk of hypertension and hypertension-related symptoms.

We would like to thank Editage (www.editage.jp) for the English language editing. This work was supported by a grant from the Japanese Society for the Promotion of Science KAKENHI (grant number: JP16K20698).

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request. The authors declare that they have no competing interests. Author's contributions is as followed: Kanetaka Yamaguchi designed the study, analyzed and interpreted the data, and wrote the initial draft of the manuscript. Junichi Karaki and Tomoya Hanatani contributed to data collection and interpretation. Takahiro Nakahara assisted in the analysis and interpretation of the data. Takaki Fukuizumi, Katsumi Hidaka, and Tatsuji Nishihara critically reviewed the manuscript. All authors approved the final version of the manuscript and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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55歳以上の日本人製造業労働者における歯科的項目と心疾患イベントハイリスク群との関連－横断研究－

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抄　録

55歳までの中高年において高血圧は心疾患イベントの発生を高める。先行研究において、40～65歳の高血圧症の日本人労働者における心血管イベントの発生リスクに職業性ストレスが関与していることが報告されている。一方で、う蝕，歯周病，歯の喪失に関して高血圧との関連が示唆されている。そこで本研究の目的は55歳以上の日本人製造業労働者における心疾患のハイリスク群と歯科的項目との間の関連性を評価することである。

この横断研究は交絡因子の傾向スコアを算出し，傾向スコアを調整後に実施された．心疾患発症リスクが高い群はコントロール群と比較した際，う蝕歯数が多く，処置歯数が少なく，歯周病の状態が悪い傾向にあった($p < 0.05$)．一方で，現在歯数には有意差はなかった．

このことから55歳以上の日本人製造業労働者において歯科的項目が悪い対象者においては心疾患イベント発症の増悪因子の一つになっているかもしれないことが示唆された．

キーワード：歯科的項目，高血圧，日本人製造業労働者，傾向スコア

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九州歯会誌　73(1)：11～18，2019.

Relationship between lateral guidance and complication incidence in single implant-supported posterior crowns

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Received August 21 2019
Accepted November 27 2019

Abstract

Purpose: With the increased number of implanted and restorations placed the number of incident also have increased. The purpose of this study was to evaluate the relationship between lateral guidance and the incidence of complications in single implant-supported posterior crowns.

Methods: 40 patients, with a total of 70 implants and restorations, were divided into two lateral guidance categories of canine guidance (CG: 19 subjects) and group function (GF: 21 subjects). Next, three major complications composed of dental implant failure, abutment connecting screw loosening and crown needing re-cementation were evaluated in each of the two lateral guidance groups.

Results: The incidence of implant fixture failure occurred significantly more often in GF than in CG (5.3% vs 0 %, $p<0.01$). GF also tended to have a higher incidence of screw loosening than CG (13.2% vs 9.4%, $p=0.4149$). However, CG tended to have a higher incidence of re-cementation than GF (21.9% vs 13.2%, $p=0.1557$). Although there was no significant difference between the two groups ($p=0.7007$), GF tended to have more occurrences of complications than CG with regard to the first year from the Kaplan-Meier survival estimation method. The overall success rate of osseointegration in this study was found to be 97.2% (68 of 70 implants).

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Conclusions: GF had significantly more implant-failure incidences than CG. Although there was no significant statistical difference, GF tended to have more occurrences of complications with regard to the first year and abutment connection screw loosening than CG. These results suggest CG is a better lateral guidance for single implant-supported posterior crown in clinically than GF.

Key words：Lateral guidance/ Complication incidence/ Single implant-supported posterior crown

Introduction

Many studies of single-tooth implants have reported implant successes greater than 95% after restoration with single crowns. In a study of single-implant restorations [1], a 96.8% implant survival was reported over an average of 18 years. Zembic et al[2] reported a 96.3% cumulative implant success rate for single-tooth restorations after 11 years. Guo et al[3] reported a 93.9% cumulative implant success rate for single-tooth restorations after 5 years.

With the increased number of dental implants being surgically placed and restored, more observations of complications have occurred. The first report about complications for single-molar implant-supported crown was reported by Becker et al[4]. They reported on 24 implant crowns fabricated in 22 patients with a 38% incidence of abutment screw loosening. Twenty-one of the 24 molar crowns were screw-retained to standard stock abutments coupled on 3.75 mm diameter implants. All restorations placed were the mesiodistal width of an average molar tooth. Screw loosening, fracture of veneering materials and the need for re-cementation were also observed in their study as well as in studies by other researchers[5-8].

Although these incidents were considered to be related to lateral guidance, there is currently no report examining this relationship thus far. The purpose of this study is to evaluate the relationship between lateral guidance and complication incidence in single implant-supported posterior crowns. In this study, three major complications of dental implant failure, abutment connecting screw loosening and crown needing re-cementation were evaluated in two lateral guidance groups.

This retrospective study was conducted under the approval of the Kyushu Dental University Research Ethics Committee (approval No. 17 - 36).

Material and methods

1. Subjects

The subjects of this study were 28 males and 12 females who were treated with implant for premolar or molar defects in a private dental clinic in United States from 2010 to 2015. All patients were partially edentulous, healthy individuals, with no significant past medical history. All patients received medical clearance from their physician. The patient's ages at the time of prosthetic restoration ranged from 23 to 66 with a mean age of 43.9 ± 12.9 y.

Patients were divided into two lateral guidance types of canine guidance group (CG: 19 subjects, 12 male, 7 female, age of 44.0 ±14.5y.) and group function group (GF: 21 subjects, 16 male, 5 female, age of 43.7 ±11.7y.).

2. Dental implant

Dental implants of root form endosteal type with an internal hex connection such as Legacy 3™(Implant Direct, USA), Swiss Plus™ (Implant Direct, USA), and Tapered Self-Thread implant™ (Hi-Tech implant, USA) were placed in this study. All the implants were placed and restored between 2010 and 2015, with recall from 6 month to 5 years. The implants in this study had been in function from 6 months up to 5 years with a mean functional period of 4 years 9 months.

3.Treatment procedure

The dental practitioner followed the Implant Direct surgical drill guides and placed the dental implants following their suggested surgical protocol. All patients were treated with a 2-stage surgical protocol[9]. At the second-stage surgery, healing abutments were placed

to help reshape the gingival tissue for 2 weeks. Afterwards, healing abutments were replaced with the stock abutment and restored with acrylic resin crowns and a provisional cement (TempBond™, Kerr, USA) for another 2 weeks prior to the final impression for lab fabrication of the definitive restoration. Premolar size crowns were fabricated when 4.00 mm (or less) diameter implants were placed. Molar size crowns were fabricated for implants with a size of 4.00 mm or greater. All of the permanent restorations were cemented with TempBond™ for the ease of prosthetic retrievability for maintenance or screw loosening complications. Maximum intercuspation with no excursive interferences was achieved for all of the restorations. Then the contacts between the cusps of crowns were checked when lateral excursion. The cusps of crowns in CG were adjusted to separate between the cusps and the cusps of crowns in GF were adjusted to make contacts between the cusps.

4. Evaluation of complications

The three major complications of dental implant failure, abutment connecting screw loosening and crown needing re-cementation were evaluated in the two lateral guidance groups. Dental implant failure was defined as the loss of osseointegration and the presence of clinical mobility. In this study, comparison between the three types of implants was not performed because of the small number of implants.

5. Statistical analysis

Differences between the two groups of lateral guidance was compared by Fisher's exact test analysis. The cumulative survival rate of the 70 implants between the two groups was assessed by the Kaplan-Meier survival estimation method. To test for differences in the survival rate curve, we used the generalized Wilcoxon test with Peto-Prentice. A p-value of < 0.05 was considered statistically significant.

Results

Evaluation and follow up of single implant-supported posterior crowns were performed as follows.

For stage 1, all implants placed in patients were examined during follow-up post-operation appointments 24 hours, 1 week, 1 month and 3 months before the second stage surgery was performed to place the abutment. Most patients felt well on all the post operation appointments with no major complains or complications. Some patients did have sutures loosened before the first-week post-operation appointment but otherwise no infection, pain or tissue swelling was observed.

For stage 2, none of the patients exhibited any pain, bruises, or complications after exposing the soft tissue to locate the fixture. A laser device was used to expose the cover screw and to locate the implants fixture. The placement of healing abutments for two weeks all had satisfactory outcomes with desired soft tissue shape for the final restorations. All restorations cemented on implants went through 24 hours, 1 week, 1 month and 3 months follow-up appointments as in stage 1. There were no occlusal adjustments necessary at first 24-hours appointment. Most of the occlusal adjustments occurred at 1-week follow-up appointments, with few exceptions at 1 month or 3 months. Some patients did need more than one adjustment but most were fine after one adjustment.

Table 1 shows the quantity, type and location of implants used in this study. A total of 70 implants were placed. 26 were in the maxillary premolar region, 13 were in the mandibular premolar region, 15 were in the maxillary molar region, and 16 were in the mandibular molar region.

Table 1 40 patients and total 70 implants fixtures summary.

Dental Implant Fixture (company)	Number of fixtures	Maxilla Premolar	Mandible Premolar	Maxilla Molar	Mandible Molar
Legacy 3 (Implant Direct)					
3.2 diameter 3.0 platform 3.2 x 6	6	1	5	0	0
3.7 diameter 3.5 platform 3.7 x 10	21	4	1	4	12
4.7 diameter 4.5 platform 4.7 x 6	2	0	0	2	0
Swiss Plus (Implant Direct)					
3.3 diameter 3.7 platform 3.7 x 10	12	3	5	2	2
4.8 diameter 4.1 platform 4.8 x 6	2	0	0	2	0
Tapered Self-Thread (Hi-Tec Implant)					
3.3 diameter 3.5 platform 3.3 x 8	4	2	2	0	0
3.75 diameter 3.5 platform 3.75 x 10	20	16	0	2	2
4.2 diameter 4.5 platform 4.5 x 8	3	0	0	3	0
Total number of fixture	70	26	13	15	16

Table 2 shows the division of 40 patients into CG and GF groups of 19 patients 21 patients, respectively. The total numbers of implants placed in CG and GF are 32 and 38 respectively.

Table 2 Lateral guidance groups and number of fixtures

Lateral guidance	Number of patients	Number of fixtures placed
CG	19(47.5%)	32(45.7%)
GF	21(52.5%)	38(54.3%)
total	40(100%)	70(100%)

Table 3 shows 3 major incident types observed during the 5 years. Amongst the 70 implants placed between 2010 and 2015, only 2 implant failures occurred. One failure was a Legacy 3 (3.7 x 10) and another one was a Tapered Self-Thread (3.75 x 10). Both failures occurred in the posterior maxillae of non-medically compromised patients. One of the failures occurred at maxillary left first molar, while the other failure occurred at maxillary left first premolar. The molar implant was in function post restoration for only 3 months, and the premolar failed implant was in function for about 18 months post restoration. The overall success rate of osseointegration in this study was found to be 97.2%, with 68 of the 70 implants being considered successful during the 5 years of follow up and recall. 8 screw loosenings were observed in five patients and 12 re-cementations were observed in eight patients.

Table 3 Distribution of 3 type incidents observed

Incidents	Max PM (26)	Max M (15)	Mand PM (13)	Mand M (16)	Total incidents of implants	Total incidents of patients
Implant failure	1	1	0	0	2	2
Screw loosening	4	2	0	2	8	5
re-cementtation	3	5	2	2	12	8

Table 4 shows the further breakdown of the incidents between the two groups. Incidence of implant fixture failure occurred significantly more in GF than in CG (5.3% vs 0 %, $p<0.01$). GF also tended to have more incidence of screw loosening than CG (13.2% vs 9.4%, $p=0.4149$). However, CG tended to have more incidence of re-cementation than GF (21.9% vs 13.2%, $p=0.1557$). Re-cementation was the most frequently observed complication among the 3 complications in both group.

Table 4 Number of incidents in each lateral guidance groups

	CG 19 patients, 32 fixtures		GF 21 patients, 38 fixtures		p-value (Number of fixture)
Incident type	Number of patients with incidents	Number of fixture with incidents	Number of patients with incidents	Number of fixture with incidents	
failure	0(0%)	0(0%)	2(9.5%)	2(5.3%)	p<0.01
Screw loosening	2(10.5%)	3(9.4%)	3(14.3%)	5(13.2%)	NS(p=0.4149)
re-cementation	3(15.8%)	7(21.9%)	5(23.8%)	5(13.2%)	NS(p=0.1557)

Table 5 shows the result of the recurrence of the re-cementation between the two groups. The results shows that, in the GF group, 5 patients needed re-cementation and 2 of them need to re-cement more than once. In the CG group, 3 patients needs re-cementation and only 1 patients need re-cementation more than once. However, there was no significant difference between the two groups (one time: $p=0.8406$, more than 1 time: $p=0.3422$).

Table 5 Recurrences of re-cementation in each lateral guidance groups

time	Number of patients (CG)	Number of patients (GF)	p-value
1 time	2(0%)	2(9.5%)	NS(p=0.8406)
More than 1 time	1(10.5%)	3(14.3%)	NS(p=0.3422)

Fig.1 shows the cumulative survival rate of the 70 implants between the two groups by the Kaplan-Meier survival estimation method. In this figure, "break down" was considered to have taken place at the occurrence of any of the three complications. During the 5 years, there were 10 incidents in CG and 12 incidents in GF. Mean survival time was 38.9 months (Max. 54 months, Min. 1 month) in CG and 38.3 months (Max. 55 months, Min. 1 month) in GF. Although there was no significant difference in the two groups (p=0.7007), GF tended to have more incident occurrences than CG with regard to the first year.

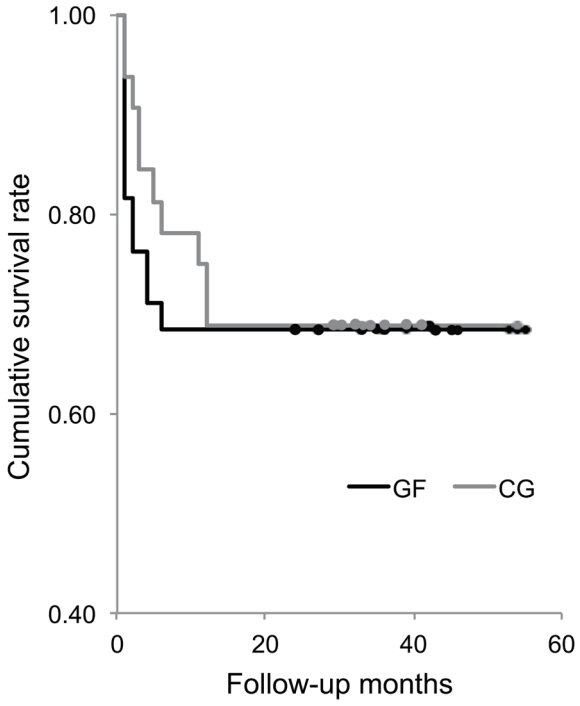

Fig.1 Cumulative survival rate of the 70 implants between the two groups
There was no significant difference between the two groups (p=0.7007).
"Break down" was considered to have taken place at the occurrence of any of the three complications.

Discussion

Usually when the practitioners follow the clinical acceptable protocols in initial diagnosis, treatment planning, surgical procedure, and prosthetics restoration, the risk of implant failures is extremely low. Ten-year survival rates of osseointegrated implants are still over 95%, but there will always be those who fall into the unlucky 5% of implant failure[7,8] .

Both group of patients in this study were in healthy condition, with good oral hygiene, and not taking any medication. All patients are underwent the same surgical procedure and were restored with the same material of porcelain fused to metal crown and cemented with a provisional cement. Yet, in this follow up study, both patients with implant failures are observed in GF while none occurred in CG.

Several studies in the past two decades of the implants placed were followed between 1 and 5 years with restoration[5,6,10,11]. Gomez-Roman et al[11] reported a 95.3% survival rate for 376 implants from one to five years.

Implant failures usually fall into two categories. Firstly, late failure describes the situation where an implant has initially integrated successful, but over time bone loss occurs around the fixture. Secondly, early failure describes the situation when an implant is placed but fails to complete osseointegration process. The causes of both of these two failures can be different. Patient may not have taken adequate care of the dental implants, and poor oral hygiene will promote bacteria growth and result in peri-implantitis. Bruxism or improper occlusion may also cause undesired force and pressure on the restoration, eventually leading to fixture failure. Chronic health conditions such as diabetes, autoimmune disorders, or osteoporosis also contribute to implant failure[12]. Certain medications such as cyclosporine, glucocorticoids, alcohol, selective serotonin reuptake inhibitors, nonsteroidal anti-inflammatory drugs, bisphosphonates may increase the risk for losing implants[13]. Lastly, improper surgery technique can also result in infections, such a prolonged exposure after flap the gingival tissues or incorrect placement of implant into sinus space around maxillary

posterior teeth region[14].

In this study, the two patients each fall into one category of early and long term failure. One implant only survived for three months. Although the fixture and restoration appeared to be functional with no mobility, the osseointegration of the maxillary molars region may either be slowed or incompleted three months post surgery. For the patient with premolar implant, failure may be attributed to bruxism and incorrected excessive occlusal force. This patient was also given an occlusal guard after heavy occlusion was noticed in the follow up appointment. This patient was however uncooperative about wearing it. After the failure occurred, she told the practitioner that the night guard had only been worn once or twice a month.

Abutment connection screw loosening and restoration re-cementation incidents can be grouped together because they are both usually the direct result of parafunction or incorrect excess occlusal load. In comparing the two groups, CG has a lower percentage of abutment connection screw loosening in both number of patients and implant fixtures. In re-cementation incidents, GF has more incidents in number of patient, while CG has more incidents in number of fixtures. The higher incidents percentage in CG may be attributed to higher numbers of implants placed in CG. GF has the highest single re-cementation and multuple re-cementation occurrences in this study.

All the implant crowns in both group were securely restored through the application of provisional cements. Yet, on the recurrences of re-cementation incident, GF leads in both incidents of a single re-cementation and more than one re-cementation. When restorations were cemented with a provisional cement, they are easier to detect the stress point of the restoration loosening. Restoration loosening from abutment is typically the direct result of having the crown subjected to excess stress or torque. Due to parafunction and abnormal forces, the provisional cement will de-bond or the abutment connection screw will loosen. This result is consist with the principle of occlusion.

Canine guidance allows for the immediate disclusion of posterior teeth during lateral or protrusive movement. Group function is known as simultaneous contact between multiple teeth on the working side during excursive movement of the mandible. Therefore for single posterior teeth restoration, canine guidance is usually preferred, since group function may add more unfavorable force to occlusal load, although canine guidance occlusion in everyday practice may not always allow.

Retrospective studies are also limited by the lack of rigid standardization of patient care. There were no paired patient samples, split mouth treatments or splinting contiguous implants to the control group to compare to. Comparison between the three types of implants could not be performed in this study because of the small number of implants. Future work, will consider such a comparison when the number of samples are suitable.

Conclusions

Within the limitation of this retrospective study, the results have shown that the overall implant osseointegration success rate was 97.2%. GF had significantly more implant failure incident than CG. Although there was no significant statistical difference, GF tended to have more occurrences of complications with regard to the first year and abutment connection screw loosening than CG. These results suggest CG is a better lateral guidance for single implant-supported posterior crown in clinically than GF.

The authors have no conflict of interest directly relevant to the content of this study.

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シングルインプラント支持型臼歯部上部構造における側方ガイドと合併症の関係

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抄　録

目的：インプラント修復物の増加とともにインシデント数も増加している．本研究の目的は，シングルインプラント支持型臼歯部上部構造における側方ガイドと合併症の関係について検討することにある．

方法：70本の歯科用インプラントおよび補綴装置を装着した40名の患者を犬歯誘導群(CG：19名)とグループファンクション群(GF：21名)の2群に分け，インプラント体の失敗，アバットメントスクリューの緩み，クラウン再装着の3主要合併症について2群間で比較検討した．

結果：GFはCGよりもインプラントフィクスチャーの失敗の発生率が有意に高かった(5.3％：0％, $p < 0.01$)．GFはCGよりもアバットメントスクリューの緩みが多く発生する傾向が認められた(13.2％：9.4％, $p = 0.4149$)．しかしながら，クラウン再装着の発生率はCGにおいて高い傾向が認められた(21.9％：13.2％, $p = 0.1557$)． Kaplan-Meierの生存推定法により検討したところ，GFは初年度に関してCGよりも合併症の発生が多い傾向にあったが，2群間に有意差は認められなかった($p = 0.7007$)．本研究におけるインプラントオッセオインテグレーションの成功率は97.2％であった．

結論：インプラント体の失敗では，GFはCGよりも有意に多く，有意差は認められなかったが，GFはCGよりも初年度の合併症の発生率やアバットメントスクリューの緩みが多い傾向が認められた．以上の結果より，臨床的にシングルインプラント支持型臼歯部上部構造における側方ガイドとしてはGFよりもCGが優れていることが示唆された．

キーワード：側方ガイド／合併症／シングルインプラント支持型臼歯部上部構造

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九州歯科学会雑誌　第73巻第1号

令和元年11月25日発行
発行所　九州歯科学会
〒803−8580　北九州市小倉北区真鶴2−6−1
九州歯科大学内
TEL・FAX　093−571−9555
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URL: http://kyu-dent-soc.com/
郵便振替口座　01700−5−32794
発行者　清水博史
編集　M's クリエイト
北九州市門司区社ノ木1−3−17
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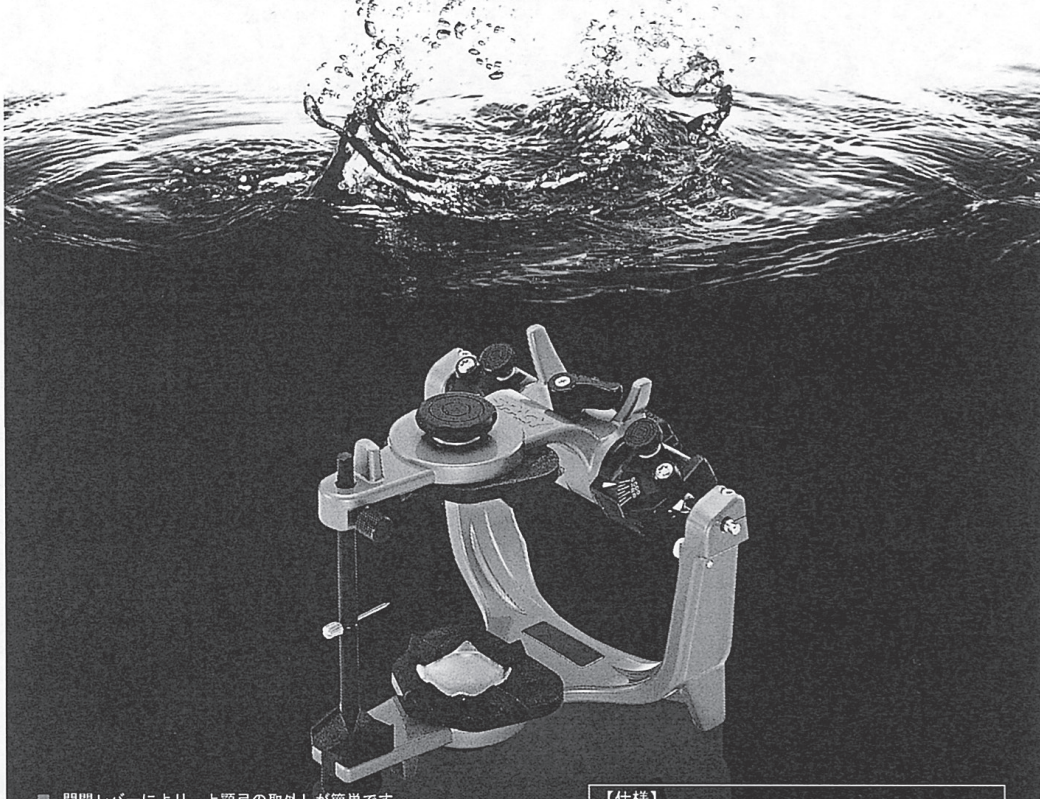

- 開閉レバーにより、上顎弓の取外しが簡単です。
- 下顎フレームの後方スペースが広いので、作業がしやすくなっています。
- 上顎弓を開口した際、咬合器が後方へ転倒しずらい設計です。
- 咬合器を逆さにしても、上顎弓の3か所の突起により安定して置けます。
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上下顎フレーム間距離　100mm
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矢状顆路傾斜角　0～60°（5°刻み）
側方顆路角（ベネット角）　0～30°（5°刻み）
バルクウィル角　20°
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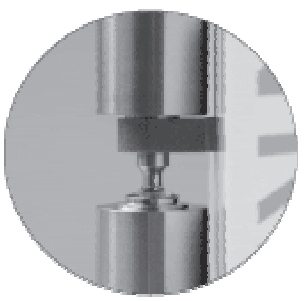

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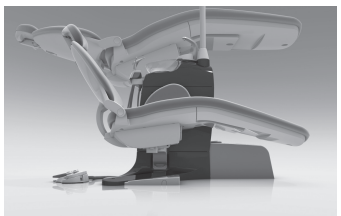
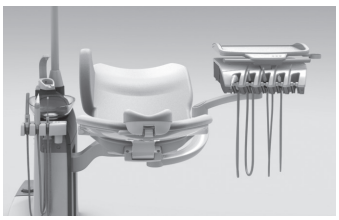


チェアのもっとも低い位置が40cm※1で、段差もなく乗り降りが楽にできます。さらにもっとも高い位置が80cmですので、外科処置などに適しています。カンターチェアは、包み込まれるような新型バケット形状で優しくお迎えします。

※1 カンター・ステップなしの場合。
チェアタイプで最低位は40～49cmと異なります。

ユニット&アーム

洗練されたフォルムが生み出す
「すっきり快適なスペース」



チェアの下台をなくしたことにより、術者の足元がすっきりし、診療しやすくなっています。しかも、テーブルアームは、先生方の診療スタイルやお好みに合わせて4タイプからお選びいただけます。

テーブル

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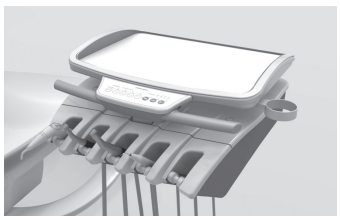

テーブルのハンドルを左右両側に設置することで、どんなポジションからもテーブルを操作しやすくなりました。しかも、操作パネルを最小限にしていますので、シンプルで使いやすいデザインになりました。

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