Abstract: This study was performed to evaluate the usefulness of a developed clinical pathway (CP) to determine the sequence of dental treatment in patients who are edentulous and use maxillary and mandibular complete dentures. Sixty-two edentulous patients with maxillary and mandibular complete dentures were randomly allocated either to with (31 subjects) or without (31 subjects) a CP. The main categories of the CP were the examination, instructions, practice, idle time, evaluation sheet, preparation, and other steps. The subcategories were made with respect to the main categories. The participants were categorized as dentists, assistants, or patients. There was no significant difference in mean chair time between with a CP (27.5 min) and without a CP (28.0 min). The CP led to a significant reduction in idle time (waiting in the chair or no treatment) of dentists, assistants, and patients. In contrast, the instances of medical examination, patients’ instructions, and the number of patients reporting improvement of symptoms significantly increased. These results indicated that there is an opportunity to improve the complete denture treatment with a CP.

Keywords: gerodontontology; treatment outcome; chair time; elderly patients; development; efficiency.

Introduction
Currently, approximately 26.7% of the Japanese population are older adults (aged 65 years or more). Despite being edentulous, they have a good quality of life (QOL) that is not affected by oral health problems if they are satisfied with their dentures (1). Therefore, high-quality prosthodontic therapy, especially a removable prosthesis, is important to ensure the QOL in this population. For the elderly patients, efficient treatment is necessary to provide a less demanding experience for them. However, criteria for establishing the appropriate clinical pathway (CP) have not been defined in prosthodontic therapy for the elderly. There may be merit in evaluating the extent of the CP which will lead to efficient prosthodontic therapy for the elderly.

Since the first concept of the CP was reported and adapted for use in healthcare by Zander in 1985 (2,3), the CP has been widely used in the U.S. as a method to provide efficient medical treatment (4-6). In Japan, CPs have been implemented in hospitals since the 1990s (7-10). In dentistry, CPs have mainly been used for oral surgery (11) and multidisciplinary collaboration-based treatment (12). However, some previous studies mentioned that CPs were used for dental and medical outpatients. Therefore, the purpose of the study is to develop a new CP to evaluate complete maxillary and mandibular dentures during follow-up.

Materials and Methods
Participants
Participants were grouped as dentists, assistants, and patients as follows:
Dentists: The study with a CP had 14 dentists with
2-28 (mean 9) years of clinical experience and the study without a CP had 14 dentists with 3-22 (mean 8) years of clinical experience participating.

Assistants: Young dentists participated as assistants during the studies. Each of 12 young dentists who had 1-2 (mean 1.7) years of clinical experience and 10 young dentists who had 1-4 (mean 2.8) years of clinical experience participated as assistants for the study with and without a CP. The assistants were chosen randomly.

Patients: Sixty-two patients who were edentulous using maxillary and mandibular dentures were provided denture adjustments during follow-up at the Department of Geriatric Dentistry, Showa University Dental Hospital and enrolled in this study. Selection of the patients was not restricted by any medical conditions they had; however, they needed to be able to communicate with us to answer the questionnaires. Thirty-one patients (12 males and 19 females) whose ages at the time ranged from 72 to 90 years (mean 81 ± 9) were in the group without the CP and another 31 patients (14 males and 17 females) whose ages at the time of the study ranged from 69 to 95 years (mean 82 ± 13) were in the group with the CP. Patients who wore both complete dentures for at least 1 month after delivery and were stable were included.

Research outline
The observation period was defined as the time of denture adjustment, which is the duration of follow-up for dentures. However, patients who required application of tissue conditioning, repair of their dentures, or fabrication of new dentures were excluded. The pilot study (without CP) and present study (with CP) were performed between June 1, 2011 and June 30, 2012, and between June 1, 2014 and June 30, 2015, respectively. The data were recorded by one investigator in the pilot study and one in the present study. The present study is a descriptive data analysis of the frequency of 6 variables (see the Comparison with and without CP section for the details) to compare it with the pilot study’s data. Figure 1 shows the research flow from the pilot study to the present study.

Without CP
The pilot study was a previous study by Isshiki et al. (13) and Kawata et al. (14) to evaluate the procedures for complete denture adjustment without a CP between June 2011 and June 2012. Adjustment of the complete dentures was recorded on a video (13), which was positioned behind the dental unit to protect patients’ privacy. The angle of the camera was adjustable so that the patients’ faces were not clearly visible. Questionnaires were administered to dentists and patients after dental treatments. The observation period was defined as the time of delivery and was stable were included.

Developed the new CP for dentures adjustment

Introduced CP (with CP) :31 patients

Exclusion

Questionnaires were administered to dentists and patients after dental treatments.

Compared between without and with CP:

1) Differential between three groups of participants
2) Mean chair time
3) Correlation between chair time and dentists’ clinical experience
4) Time of each item
5) Number of preparations and orders by dentists
6) Questionnaires to attending dentists and patients
7) Patients’ symptoms

*2-7): compared six variables between without and with the CP

Fig. 1 Research flow

were administered to dentists and patients to measure the subjective improvement of patients’ symptoms. The question to dentists was, “Have the treatments performed today improved the patients’ symptoms?” and the second question, to patients, was “Have your symptoms improved after the treatments?” The response scales for the questions were as follows: markedly improved, slightly improved, slightly deteriorated, or markedly deteriorated. The patients filled out the questionnaire in the absence of the dentists. The timetables were marked off every 30 seconds for the observation subjects and were categorized into 7 main categories and 17 subcategories (Table 1). The main categories considered for an examination were instructions, practice, idle time [blank time (13)], preparation, evaluation sheets, and other steps. The idle time refers to the time during which any dental treatments were not provided by dentists or assistants and which is effectively waiting time for patients.

Developed CP
The new CP for complete denture adjustment after the previous study without a CP was developed following Dr. Spath’s (Spath P. Succeeding with Critical Paths. Forest Grove, Oregon: Brown-Spath & Associates, 1993: 1-5, 75-76) CP. Dr. Spath’s clinical pathway had a path sheet with diseases and treatments (progression of time shown on the vertical axis, category of care shown on the horizontal axis in Fig. 2), in order to identify variances (i.e., denture repair and tissue conditioning). The sequence of denture adjustment followed previous dental treatments [Isshiki et al. (13)] and textbooks by Dr. Winkler (Winkler S. Essentials of complete denture prosthodontics. Philadelphia: W.B. Saunders, 1979: 467-479) and Dr. Yamagata (Yamagata K, Kuroiwa A. Illustrated edentulous prosthetics. Japan: Gakkensyoin Co., Ltd., 2004: 225-243 in Japanese). According to
Adachi et al. (11), although evidence-based medicine is necessary for a CP introduction, evidence for every disease is not available. In particular, the CP has had very limited use for dental treatments. To develop a new CP, retrospective data and standardize medical practices are necessary.

Therefore, the aforementioned Dr. Spath’s CP, textbooks, and our previous study were the references. The previous study showed that the idle time of patients and assistants has accounted for approximately half of their total chair time for complete denture adjustments. During their idle time, the patients filled out the evaluation sheets, which included denture satisfaction (15), chewing function (16), and QOL (17). The dentists used the results of the evaluation sheets for patients’ instructions. The assistants helped the dentists, including polishing dentures after adjustment and entering information into patients’ medical records. Subsequently, the variances that deviated from the expected outcomes in the CP (18) were analyzed. In this study, the variances were denture repair and tissue conditioning.

**Comparison with and without CP**

Thirty-one patients were provided denture adjustments with the CP. The categories shown in Table 1 were named by three different groups of participants: 1) dentists, 2)
The set value between slightly improved and markedly deteriorated, or (4) markedly deteriorated. The cutoff was reported (1) markedly improved (improved group) and (2) improved, because patients who were slightly improved did not have all of their symptoms improved yet and this indicated that some problems remained. The chi-square test was used to compare the 2 groups respectively.

6) To evaluate the presence of patients’ symptoms during the next visit after the adjustment of the dentures, the patients were divided into groups with/without symptoms, such as looseness of dentures or soreness. The chi-square test was used to compare the 2 groups.

SPSS (SPAW Statistics Base Ver-18, IBM, Tokyo, Japan) was used to perform the statistical analysis. This study was approved by the ethics committee of the Showa University School of Dentistry (approval number: 2011-004).

**Results**

**Variances**

Based on the collection and analysis of variances which were excluded from the path, the developed CP was able to provide dental treatments for individual patients. In the present study, 1 of the 31 patients (3.2%) required relining of their dentures during follow-up. Therefore, this patient was excluded from the number of subjects. The subsequent study was made based on the remaining 30 patients.

**Frequency**

Table 2 shows the frequency of patients undergoing each item of the subcategories. Although some examinations and instructions had not been provided by the dentists (denture examination with the dentist, 71% and patient education, 16%) during follow-up without a CP, use of the developed CP helped improve the frequency of providing.

### Table 2 Frequency of each category in 3 groups of dentists and assistants

| Main categories | Sub categories          | W/O CP | W CP |
|-----------------|-------------------------|--------|------|
| Examination     | Medical interview       | D: 90% | A: 0%| D and A: 100% | D: 100% | A: 0%| D and A: 100% |
|                 | Oral examination        | D: 90% | A: 0%| D and A: 100% | D: 100% | A: 0%| D and A: 100% |
|                 | Denture examination     | D: 71% | A: 0%| D and A: 100% | D: 100% | A: 0%| D and A: 100% |
|                 | Fitting                 | D: 90% | A: 0%| D and A: 100% | D: 100% | A: 0%| D and A: 100% |
|                 | Occlusion               | D: 97% | A: 0%| D and A: 100% | D: 100% | A: 0%| D and A: 100% |
|                 | Medical treatment assistance | D: 0% | A: 94%| D and A: 100% | D: 100% | A: 100%| D and A: 100% |
| Instructions    | Patients’ education     | D: 16% | A: 3% | D and A: 19% | D: 100% | A: 10%| D and A: 100% |
|                 | Explanation             | D: 87% | A: 6% | D and A: 97% | D: 100% | A: 3%| D and A: 100% |
| Practice        | Adjustment              | D: 100%| A: 0%| D and A: 100% | D: 100% | A: 0%| D and A: 100% |
|                 | Polishing               | D: 94% | A: 16%| D and A: 94% | D: 3%| A: 100%| D and A: 100% |
|                 | Denture cleaning        | D: 26% | A: 68%| D and A: 74% | D: 17%| A: 100%| D and A: 100% |
|                 | Oral care               | D: 26% | A: 36%| D and A: 48% | D: 20%| A: 100%| D and A: 100% |
| Idle time       |                         | D: 48% | A: 48%| D and A: 71% | D: 13%| A: 47%| D and A: 50% |
| Preparation     | Preparation of instruments | D: 42%| A: 100%| D and A: 100% | D: 20%| A: 90%| D and A: 90% |
| Other           | Talking                 | D: 29% | A: 10%| D and A: 35% | D: 57%| A: 17%| D and A: 60% |
|                 | Medical records entry   | D: 74% | A: 55%| D and A: 100% | D: 100% | A: 100%| D and A: 100% |

D: Dentists; A: Assistants; D and A: Dentists and assistants.
the examinations and instructions for all patients (100%). According to the practice section, “Polishing,” “Denture cleaning,” and “Oral care” were provided by assistants with the CP. “Examination,” “Instructions,” and “Practice” were provided for all patients (100%) by both dentists and assistants with the CP. Additionally, the time for “Talking,” which means communication with patients, increased with the CP (i.e., with dentists, 57% and with assistants, 17%).

**Chair time**
The mean chair time with/without the CP was 27.5 ± 6.3 min and 28.0 ± 11.8 min respectively without a significant difference (P = 0.837). The coefficients of variation with/without the CP were 22.8 and 42.2, respectively. There was a marginal correlation between chair time and clinical experience of the attending dentists without the CP, (|γ| = 0.08) and with the CP (|γ| = 0.19).

**Time for each item**
The effect on time for each of the steps of treatment (items) by introducing the CP was examined. Figure 3-1 shows the comparison of time between with and without the CP in the main categories. The time for “Examination” and “Instructions” with the CP was significantly increased in all 3 participant groups (dentists, assistants, and patients) (P < 0.05 or P < 0.01). The amount of time of the “practice” with the CP was significantly decreased for the dentists while significantly increased for the assistants (P < 0.01). The idle time with the CP was significantly decreased in all 3 participant groups (P < 0.01). The time required for preparation with the CP...
was significantly decreased for the dentists and assistants ($P < 0.01$). The time for the other steps with the CP was significantly increased for the assistants because of the increase in the time required for medical record entry ($P < 0.05$).

Figure 3-2 shows the comparison of time between with and without the CP in the subcategories of “Examination” and “Instructions.” The time of oral examination, denture examination, and fitting conducted by the dentists significantly increased with the CP ($P < 0.01$). The time required for polishing by the dentists significantly decreased ($P < 0.01$), while the time required for polishing and denture cleaning by the assistants significantly increased with the CP ($P < 0.01$).

**Number of times for preparation and orders**

Figure 4 shows the comparison of the number of times for preparation and orders by dentists with and without the CP. The times required for preparation of instruments and orders by dentists significantly decreased from without the CP to with the CP (preparation: $2 \pm 2$ times/0 ± 1 times, $P = 0$ and orders: $2 \pm 2$ times/0 ± 1 times, $P = 0$). The reasons for preparation of instruments by dentists themselves mostly involved the preparation of tools for medical examination and polishing. The orders from dentists to assistants mostly comprised preparation of tools for fitting, occlusion tests, and polishing.

**Questionnaire**

Figure 5-1 shows the results from the questionnaires from the attending dentists and the patients evaluating the patients’ symptoms after the denture adjustment.

(1) Attending dentists: The proportion of patients in the improved group (wherein the dentist assessed improvement of the patients’ symptoms) did not significantly differ between with and without the CP and accounted for 90% of patients with the CP.

(2) Patients: The proportion of participants in the improved group was significantly increased with the CP and accounted for 90% of the total sample with the CP.

**Presence of symptoms at the next visit**

Figure 5-2 shows that the use of a CP cannot significantly improve patients’ symptoms ($P = 0.05$), but the number of patients who had symptoms decreased from 54.8% to 30.0%.

**Discussion**

According to a survey of dental disease in 2012 carried out at the Ministry of Health, Labour and Welfare, the prevalence in the Japanese older population who are edentulous and wear complete dentures is 28.2% among those aged 75-79 years, 42.7% among those aged 80-84 years, and 52.8% of those aged ≥85 years. Considering the great number who are using complete dentures, high-quality treatment with complete dentures is important in prosthodontics for the super-aged society in Japan. To improve the system of complete denture treatments, the new CP was developed in an attempt to apply the concept of a CP to dental treatment in elderly patients. There were several reasons to focus on only complete denture adjustment. First, a CP has been considered to be suitable for treatment frequently performed in clinical practice. Second, treatments such as impression, bite registration, and delivery of dentures are greatly influenced by patient characteristics, whereas denture adjustment is less influenced by such factors. According to the study by Kiovics et al. (19), the proportion of patients requiring
denture adjustment after installation was 87% in the first week, 50% in the second week, 7% in the third week, and 0% in the fourth week. Therefore, the patients were selected who had been wearing complete dentures for at least 1 month with stable conditions and who visited us for follow-up without any complaints.

In the studies reported by Kimoto et al. (20) and Sileversin et al. (21), there were no correlations between the length of clinical experience of the participating dentists and the length of chair time taken for denture adjustment. Therefore, in this study, the attending dentists who participated had a wide range of clinical experience. As a result, there was a marginal correlation between chair time and clinical experience of the attending dentists.

In the present study, the assistants who performed partial treatments were young dentists because there is a limited number of dental assistants and oral hygienists in our university dental hospital. Dental students are also not permitted to perform most of the dental treatment procedures.

While there was no significant difference in the mean chair time, the time of examination and instructions significantly increased with the CP. The proportion of participating patients undergoing these treatment steps also increased. In particular, the length of time of the oral and denture examination was increased. Although treatment time had not changed, the statements regarding denture treatments improved. The use of evaluation sheets could lead to finding patients who have unstable dentures because it evaluates patients’ satisfaction with their dentures. Therefore, appropriate patient education and explanations after applying the new CP were provided. According to the above results, the CP contributed to improving the efficiency of dental treatments for denture adjustments. There are 3 reasons why the chair time was not changed with the CP. First, the idle time was decreased with the CP. Before the introduction of the CP, approximately half of the chair time for patients was used during the dental visit. Therefore, the idle time was used to administer the evaluation sheets to the patients. The dentists could understand the conditions of the dentures more efficiently based on the information obtained from the evaluation sheets, which might have led to better patient education. A brief idle time might be better because nobody was engaged in an effort to perform dental treatment during the idle time. Medical interviews, patients’ education, explanations, and communication time were increased after providing the CP. Thus, the communication time could be increased with the CP.

Second, the roles of the assistants became clear. Sharing of some treatments between the dentists and assistants, such as polishing dentures, resulted in increased available time for examinations and instructions. Additionally, the amount of time of support given by the assistants increased after use of the CP (Fig. 3). The CP seemed to enhance the willingness of assistants to provide the denture adjustment. Third, the number of preparations performed by the dentists themselves and the number of orders given to the assistants decreased. The CP could improve the assistants’ understanding of the next dental procedure. Therefore, the assistants may now be able to perform the preparations that the dentists had performed themselves in the past, by themselves, without receiving orders from the dentists. Additionally, the time required for preparation by the dentists and assistants significantly decreased with the CP. Thus, smooth cooperation between the dentists and assistants led to efficient dental treatment. These results suggest that the CP contributed to achieving enhanced efficiency of the dental treatments.

The increase in treatment procedures will induce the improvement of efficiency of dental treatment. However, it will also include unnecessary treatments. On the questionnaires to the dentists and patients, the proportion of the number of patients in the improved group increased with the CP. The dentists might have tended to focus on the patients’ complaints and skip some of the examination items; however, they were found to have performed the routine examination with the CP. This might have led to the increase in the number of examination items performed and the improvement in symptoms other than the chief complaint. These results indicate the possibility that the CP improves treatment outcomes. The proportion of patients with symptoms at the next visit tended to decrease with the CP, suggesting that the CP was effective in improving symptoms. Continuous treatment in line with the CP might contribute to further improvement. These results also suggest that the dental treatment became more comprehensive and efficient with the CP.

The analysis of variance was important in the development of the CP, and its accumulation was essential to improving the effectiveness of the CP. The variance identified in the present study was required for relining the dentures. Preparation of a CP that applies to all patients undergoing maintenance care, including those requiring relining via alveolar ridge resorption, is necessary. Also, this study was limited to a CP in one treatment area for denture adjustment, and generalizability may be a concern because it was only for patients wearing stability dentures. Further studies are needed to apply the
CP while repairing or relining dentures.

According to a survey of outpatients in Japan, they frequently visit due to the dental disease; it is the third leading cause in men and the fifth leading cause in women (Ministry of Health, Labour and Welfare. Comprehensive Survey of Living Conditions, http://www.mhlw.go.jp/toukei/list/dl/20-21-h25.pdf [Accessed July 7, 2017]).

Japan is already a super-aged society. The number of elderly patients who are unable to visit outpatient clinics is expected to increase. Application of a CP to home-visit dental treatment should be a future research topic.

This study indicated that the developed CP was useful for increasing the efficiency and enhancing complete denture treatment without extending chair time. Therefore, the study suggested a possible beneficial effect of the developed CP to complete denture treatment in future gerodontology.

Acknowledgments
The authors wish to thank all the participants, dentists, and assistants for their participation in this study and the faculty of Geriatric Dentistry at Showa University for their support. We sincerely thank Professor Koji Takahashi (Department of Special Needs Dentistry, Division of Oral Rehabilitation Medicine), Professor Tomio Inoue (Department of Physiology), and Professor Shouji Hironaka (Department of Special Needs Dentistry, Division of Hygiene and Oral Health) for their support. This study was partly supported by a 2014-2016 Grant-in-Aid for Scientific Research (Japan Society for the Promotion of Science, Basic Research C, Grant No.26462935). The abstract of this study was presented at the 93rd General Session & Exhibition of the International Association for Dental Research held on March 12, 2015 in Boston, U.S.

Conflict of interest
No conflict of interest exists regarding this study.

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