【Introduction】

A dentition model that reproduces the oral cavity plays an important role in dental treatment. Conventionally, a dentition model is obtained by recording the patient's dentition using an elastic impression material, pouring plaster mix into the impression, and hardening it (conventional method). In recent years, dental treatment based on digital technology, that is, digital dentistry, has been developed, and the use of an intraoral scanner (IOS) for recording impressions (digital method) is rapidly gaining acceptance. According to a study comparing the accuracy of the conventional method with the digital method, the latter is not affected by material-related factors such as deformation of the impression, breakage, and incorporation of air bubbles; hence, it is possible to demonstrate higher accuracy than the conventional method. In the digital method, a digital model is constructed by inserting the tip of an intraoral scanner into the patient's oral cavity and directly photographing the dentition. Therefore, it has been reported that in full-arch impressions made using this method, the error that occurs in the process of image construction by continuously stitching captured images affects accuracy. In addition, in areas of crowding, where teeth overlap, light does not reach the details and a blind spot occurs. Therefore, it is necessary to re-record the defective part for image construction, by moving the tip of the scanner to measure from multiple directions. Thus, in the application of the digital method in the field of orthodontics, it is assumed that the degree of crowding that a patient has affects the accuracy of the digital dental model. Therefore, in this study, we used a non-contact three-dimensional measuring instrument that can acquire high-resolution data, and compared the accuracy of the dentition model obtained by the conventional method with the digital method. Further, we examined the effect of years of clinical experience on the impression acquisition method.

【Materials and Methods】

1.Selection of reference model and preparation of gold standard (STD)

In this study, we used a parallel model made for 3 patients with different degrees of crowding (mild, moderate, and severe), based on the latest criteria for tooth extraction. The morphological information of each parallel model was acquired using a non-contact three-dimensional measurement system, and the resin model created using a 3D printer was used as the reference

model. After applying a layer of model coating material to the surface of each reference model, morphological information was acquired by a non-contact three-dimensional measurement system, and this data was designated as the gold standard (STD).

2.Modeling and digital data acquisition by conventional methods
Conventional impressions of the reference models were made using two types of impression materials – alginate impression material and silicon impression material. Impressions were made three times by the same surgeon. After making the impression, a plaster model was formed with cemented carbide gypsum, and the morphological information of the model was acquired using a non-contact three-dimensional measuring instrument. Only the dentition data were extracted from the acquired digital data using three-dimensional analysis software, and the alginate impression material was designated as the AI group and the silicon impression material was designated as the SI group.

3.Acquisition of digital data of reference model by digital method.
In this study, each reference model was attached to the phantom, and impressions were made three times for each model using TRIOS 3 of 3Shape. Using three-dimensional analysis software, only the dentition data were extracted from all the acquired digital data and designated as the IOS group.

4.Dividing and superimposing digital dentition models
The acquired dentition data of each group were divided into three blocks of the right molar, anterior, and left molar using 3D analysis software. To compare the STD and various divided-dentition data, the best-fit algorithm method was used to superimpose the two data.

5.Evaluation method of accuracy of digital dentition model
The accuracy of the various divided-dentition data with reference to the STD was evaluated using the root mean square error (hereinafter abbreviated as RMS error) with a three-dimensional analysis software. A two-way ANOVA was used for statistical analysis. ($p<0.05$) Furthermore, the surface deviations of the two superimposed data were calculated, and the amount of deviation was shown in a color mapping image for visual evaluation.

6.Assessing the impact of years of clinical experience on digital impression
For each standard model, a total of 10 dentists, 5 with clinical experience ≤3 years, and 5 with ≥4 years, performed the digital method. The acquired digital data were saved in STL format. Using three-dimensional analysis software, the RMS error was calculated by superimposing each dentition data obtained by the digital method and STD. A two-way ANOVA was used for statistical analysis. ($p<0.05$)

【Results】
1. Accuracy evaluation of conventional method and digital method
The RMS values of all parts of the upper and lower jaws showed the largest values in the order of AI group> SI group> IOS group. The digital method did not show any significant difference in RMS values for different degrees of crowding. On the other hand, in the conventional method, an increase in RMS error with an increase in crowding was observed in some comparisons in both the AI and SI groups. In the conventional method, both the AI and SI groups showed a large RMS error in the anterior teeth.

2. Evaluation of surface deviation by superimposed image
In the conventional method, the difference from STD increased in the cervical region, occlusal fissures, palatal surfaces of the maxillary anterior, and lingual surfaces of the mandibular anterior. Point-like deviations were observed in the occlusal fissures and cervical regions of both the upper and lower jaws. With the digital method, there was little change with increasing crowding.

3. Assessing the impact of years of clinical experience on the digital method
No significant difference was found in the comparison between the two groups with different years of clinical experience.

【Discussion】
The results of this study showed that the digital dentition model has higher accuracy than the dentition model obtained by the conventional method. As described in the earlier, it was considered that the cause of this was that the digital method was not affected by material-related factors such as

deformation of impression and incorporation of air bubbles. In other words, because the undercut area increases due to crowding, in the conventional method using elastic impression material, the deformation that occurs when the impression material is removed affects the accuracy. The fact that the digital dentition model in the conventional method showed a large RMS value, especially in the anterior teeth with severe crowding, indicated that the physical properties of the impression material had a considerable effect. The punctate anomalies observed in the occlusal fissures and cervical region were due to the inclusion of air bubbles during the mixing of the impression material and the injection of plaster during model formation. In addition to the high performance of the device, the digital method had little effect on accuracy even if the amount of crowding in the dentition increased and it demonstrated stable and high accuracy regardless of the operator's years of clinical experience. It was suggested that one factor is the simple operability such that the surgeon can check the monitor during the impression-making process.

【Conclusion】

The following conclusions were obtained from the results of this study.

1. The digital method exhibits higher accuracy than the conventional method, regardless of the degree of crowding.
2. The number of years of clinical experience of a dentist does not affect the accuracy of the digital dentition model using the digital impression method.

These results suggest that the digital method is useful in orthodontic treatment of the crowded dentition.