

Clinical Paper
Orthognathic Surgery

Hard and soft tissue changes and long-term stability after vertical height reduction genioplasty using biodegradable fixation

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Abstract. The aim of this work was to analyse the stability of vertical height reduction genioplasty using biodegradable material, as well as to determine vertical changes of hard and soft tissues during this procedure.

Forty patients underwent vertical height reduction genioplasty using two types of biodegradable fixation (Biosorb FX[®] or OSTEOTRANS-MX[®]), combined with mandibular setback surgery. We assessed lateral cephalographs over time (pre-operation; immediately post-operation; 3 months, 6 months and 12 months post-operation).

We found a mean vertical difference of 0.22 mm (standard deviation (SD) = 0.49 mm) at the menton point immediately post-operation, compared with 12 months post-operation. And there was no statistical significance ($P > 0.05$). The chin hard tissue remained stable from the immediate post-operation period to 1 year post-operation, and the chin soft tissue remained stable from 3 months to 1 year post-operation. The regression equation describing the replacement of hard tissue with soft tissue change, between pre-operation and 12 months post-operation is $y = 0.590x + 0.885$ ($R^2 = 0.300$, $P < 0.001$).

We confirm that the use of biodegradable fixation is a stable method, in terms of skeletal tissues, and a relatively stable method, in terms of soft tissues. In vertical height reduction genioplasty, soft tissue does not reflect 100% of the vertical tissue reduction in hard tissues. This data may influence establishment of surgical treatment objectives.

Key words: vertical height reduction genioplasty; biodegradable fixation; vertical macrogenia.

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The chin is an important aspect of the overall impression of the face, and the proper size and shape of the chin play a crucial role in providing a harmonious facial shape. Genioplasty is an operation method that is utilized for improving disharmony of the chin and improving facial aesthetics; it was used through an intraoral approach for many years after the initial introduction of the surgical technique by Trauner and Obwegeser in 1957¹.

Initially, a bone fragment was fixed with a wire after genioplasty; then, a method of internal rigid fixation, using a metal plate and screw, was developed and actively used¹⁻⁴. Recently, a biodegradable material has been developed to fix a bone fragment; several studies have been conducted regarding the stability of facial bone surgery using biodegradable materials⁵⁻¹⁰.

Genioplasty can be performed in an anteroposterior or lateral displacement of the bone fragment, in accordance with the shape of the chin; vertical height reduction genioplasty (VHRG) is performed in cases of chin vertical macrogenia¹¹⁻¹³. Throughout the history of genioplasty, there have been multiple investigations into the stability of genioplasty, based on the fixation method used¹⁴⁻¹⁸. However, there have been few studies regarding stability and soft tissue changes after VHRG, and there has been no effort to determine sufficient stability after using biodegradable materials.

In this study, we analysed the stability of VHRG performed using biodegradable material, and measured vertical changes in hard and soft tissues during VHRG, in order to investigate the usefulness and stability of biodegradable material during chin surgery in vertical macrogenia patients and to investigate the relationship between soft tissue changes and hard tissue movement.

Materials and methods

Due to the retrospective nature of this study, it was granted an exemption in writing by the institutional review board of Yonsei University Dental Hospital (2-2017-0039). The subjects were diagnosed with mandibular prognathism with vertical macrogenia in the Yonsei University Dental Hospital Department of Oral and Maxillofacial Surgery, from January 2006 to April 2016; after completing the preoperative orthodontic treatment, all subjects underwent VHRG combined with mandibular setback surgery, performed by the same surgeon (Y.-S.J.).

Among 69 patients, 40 who were able to be followed up for at least 1 year after surgery were included in the study, except for those who underwent surgery to move the bone fragment in a direction other than vertical, such as anteroposterior or lateral movement. Patients who underwent preorthodontic orthognathic surgery, which can cause severe occlusal plane changes, and patients with craniofacial anomalies such as cleft lip and palate and other syndromic diseases, were also excluded. The male:female ratio was 23 males and 17 females; the mean age was 21.6 years old (standard deviation (SD) = 2.95). All patients underwent bimaxillary orthognathic surgery, Lefort 1 osteotomy and intraoral vertical ramus osteotomy (IVRO), with VHRG. Lateral cephalographs were taken preoperatively; immediately postoperatively; and at 3, 6, and 12 months postoperation for routine care. Forty patients were measured and compared for changes in hard and soft tissues of the chin.

VHRG was performed through a vestibular incision at the labial mucosa and the mucoperiosteal flap was raised to expose the mental foramen bilaterally. Inferior and posterior aspects of the bone fragment were left attached to the periosteum, in order to preserve the blood supply¹⁹. The reference vertical line was set in the outer bone of the exposed chin, as an indication of the amount of bone to be resected according to the operative plan; two rows of osteotomy were performed horizontally using a reciprocation saw, avoiding the apex of the teeth, the inferior alveolar nerve, and the mental nerve. The resected bone fragment was removed and the remaining distal bone fragment was fixed with two types of biodegradable

fixation plates and screws (Biosorb FX[®], Bionximplants, Tampere, Finland; OSTEOTRANS-MX[®], Takrion, Osaka, Japan). After confirming the stability of the fixed bone fragment, the muscle and mucosa were sutured.

The additional cost of biodegradable fixation, its known complications, and the risks of developing them were explained to each patient during the preoperative interview^{6,9,20}. Pre-operation permission, was requested from each patient, and biodegradable fixation was applied only to those who agreed.

Methods for evaluating changes in hard tissues and soft tissues of the chin after surgery were evaluated using a modified version of the method previously used by Kim et al.; the measurement points and measurement baselines are as follows^{7,14,16}.

OPL (occlusal plane) is a horizontal plane, tangential to the uppermost convex area of the most posterior tooth and tip of the most anterior tooth of the mandible. Me (hard tissue menton) is the most inferior point of the symphysis of the mandible; Mes (soft tissue menton) is the point on the skin of the mental area, which crosses the Me on a perpendicular line drawn from the OPL. Me(P) (post-op hard tissue menton) is the most inferior point of the symphysis of the mandible after the operation; Mes(P) (post-op soft tissue menton) is the point on the skin of the mental area, which crosses the Me on a perpendicular line drawn from the OPL, after the operation. Fig. 1 shows the reference landmarks and planes used in the study.

The measurement method was defined as the distance between the measurement point and the measurement reference line.

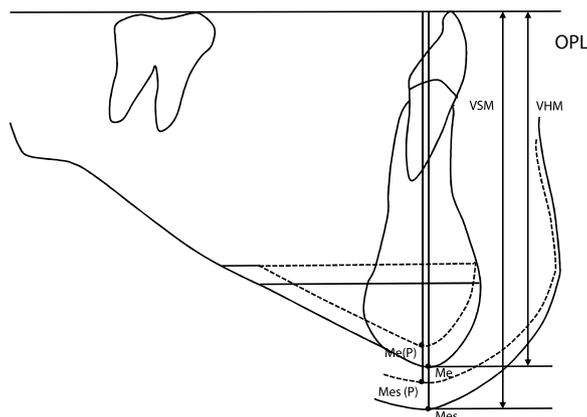


Fig. 1. Reference landmarks and planes used in the study. Solid line is preoperative tracing and broken line is postoperative tracing. Me, hard tissue menton; Mes, soft tissue menton; Me(P), post-op hard tissue menton; Mes(P), post-op soft tissue menton; OPL, occlusal plane; VHM, vertical position of hard tissue menton; VSM, vertical position of the soft tissue menton.

VHM (vertical height of hard tissue menton) is the vertical distance from OPL to Me and Me(P); VSM (vertical height of soft tissue menton) is the vertical distance from OPL to Mes and Mes(P).

To ensure accuracy of the measurements, each lateral cephalograph was measured twice by a single clinician using V-ceph 7.0 software (Osstem Implant, Seoul, Korea); a paired *t*-test was used to assess the significance of errors in measurement. Vertical changes during the postoperative period in the hard and soft tissue were analysed using descriptive statistics (mean and SD). One-way analysis of variance (ANOVA) was repeated to analyse the statistical difference between the periods. Using Pearson's correlation coefficients, we analysed the correlation between changes in hard and soft chin tissue, and the correlation between preoperative VTS and changes of soft chin tissue at 12 months postoperation. Using simple regression analysis, we investigated the predictability of soft tissue changes in the amount of hard tissues. Statistical analysis was performed using IBM SPSS Statistics for Windows, version 22 (IBM Corp., Armonk, NY, USA).

Results

There was no statistically significant difference in the repeat measurements performed to determine the accuracy of the measurements ($P > 0.05$).

To investigate the vertical changes in chin tissue caused by surgery, we compared chin tissues preoperation and immediately postoperation. The average change of chin hard tissue was -3.38 mm (SD = 0.96), whereas the average change of chin soft tissue was 0.48 mm (SD = 1.89).

To evaluate the stability of chin hard tissue after surgery, we compared chin hard tissues immediately postoperation and 12 months postoperation. The average change of chin hard tissue was 0.22 mm (SD = 0.49), which was not statistically significant (Table 1).

Table 1 shows changes in hard tissue and soft tissue during five time periods,

from immediately postoperation through 12 months postoperation. Change in hard tissue (VHM) was statistically significantly different between preoperation and immediately postoperation. Change in soft tissue (VHS) was statistically significant at 3 months postoperation, compared with immediately postoperation (Table 1, Fig. 2).

The mean change of chin hard tissues between preoperation and 12 months postoperation was -3.16 mm (SD = 1.0). The mean change of chin soft tissues between preoperation and 12 months postoperation was -0.98 mm (SD = 1.04). The Pearson correlation coefficient of changes of chin hard and soft tissues over 12 months postoperation was 0.548 ($P < 0.001$). Whereas that of the preoperative thickness of the chin soft tissue (VSM-VHM) and the soft tissue after 12 months postoperation was 0.207 ($P = 0.195$ [>0.05]). Simple regression analysis showed that the regression equation relating soft tissue changes to hard tissue changes at 12 months postoperation was $y = 0.590x + 0.885$ ($R^2 = 0.300$, $P < 0.001$) (Table 2, Fig. 3).

The complications and complaints of the patients were reviewed using the medical records and radiographic data of the patients. No surgical complications such as infection at the surgical site, foreign body sensation at the surgical site, necrosis of the bone fragment, failure of fixation of the bone fragment, dislocation of the bone fragment, and inflammation of the biodegradable fixation were found. The complaints of the patients included hypoesthesia of the chin (9/40), hypersensitivity of the teeth (1/40) and discomfort of the lips (1/40). However, all the patients recovered within 12 months of surgery. They did not continue to feel discomfort, and none of them have visited the hospital with discomfort after surgery since then.

Discussion

Initially, bone fragment fixation with a wire was the primary method utilized during genioplasty; then, rigid internal fixation, with a metal plate and screw, was developed and actively used by many

surgeons¹⁻⁴. This fixation method is reliable and has been proven over a long period of time, but it may elicit foreign object sensitivity because the wire is a metallic material²¹. In addition, additional secondary surgery is required to remove metal plates and screws because of the appearance of metal on radiographs, which may interfere with other treatment plans or cause artifacts during CT and MRI²².

Recently, a method of fixing bone fragments using biodegradable materials, such as poly L-lactide (PLLA), has been developed, and a method of fixation using unsintered hydroxyapatite particles/poly L-lactide (u-HA/PLLA) has been developed^{5,20,23}. Biodegradable materials have recently become widely used, as there is no need for removal surgery because of the disadvantages of metallic materials.²⁴ The quality of life of the patients can be improved since an additional plate removal surgery would not be required. However since this study was a retrospective study, there was a limitation in quantitatively studying the patients' satisfaction with biodegradable fixation using a questionnaire at the time of the research plan. According to Ballon et al., the preference for biodegradable fixation is higher in spite of higher cost²⁵. However, since the size, shape, and strength of the material can change with the absorption of the material over time, the characteristics of the material should be well understood and applied clinically. For this reason, studies on biodegradable materials are actively conducted.

Lee et al. reported that the stability of fixation via biodegradable screws was not different from that of metal plates, in a study of 29 patients who were fixed with PLLA screws and 29 patients who were fixed with a metal plate after advancement genioplasty⁷. Sukegawa et al. reported that the u-HA/PLLA plate showed successful fracture stabilization and re-ossification with low complications in 35 facial fracture patients⁹. Park et al. showed that when maxilla Lefort 1 osteotomy was applied to u-HA/PLLA plates in 53 patients, the anteroposterior and horizontal stability

Table 1. The amount of positional change of hard and soft tissues by vertical height reduction genioplasty.

	Preoperative to immediate ($n = 40$) Mean (SD)	Immediate to 3 months ($n = 40$) Mean (SD)	3-6 months ($n = 40$) Mean (SD)	6-12 months ($n = 40$) Mean (SD)	Preoperative to 12 months ($n = 40$) Mean (SD)	Immediate to 12 months ($n = 40$) Mean (SD)
VHM	$-3.38(0.96)^{***}$	$0.10(0.4)$	$0.10(0.2)$	$0.03(0.27)$	$-3.16(1.0)^{***}$	$0.22(0.49)$
VSM	$0.48(1.89)$	$-1.26(1.40)^{***}$	$-0.07(0.77)$	$-0.13(0.68)$	$-0.98(1.04)^{***}$	$-1.46(1.45)^{***}$

SD, standard deviation; VHM, vertical position of hard tissue menton; VSM, vertical position of the soft tissue menton.

* $P < 0.05$; ** $P < 0.01$.

*** $P < 0.001$, repeated one-way analysis of variance test.

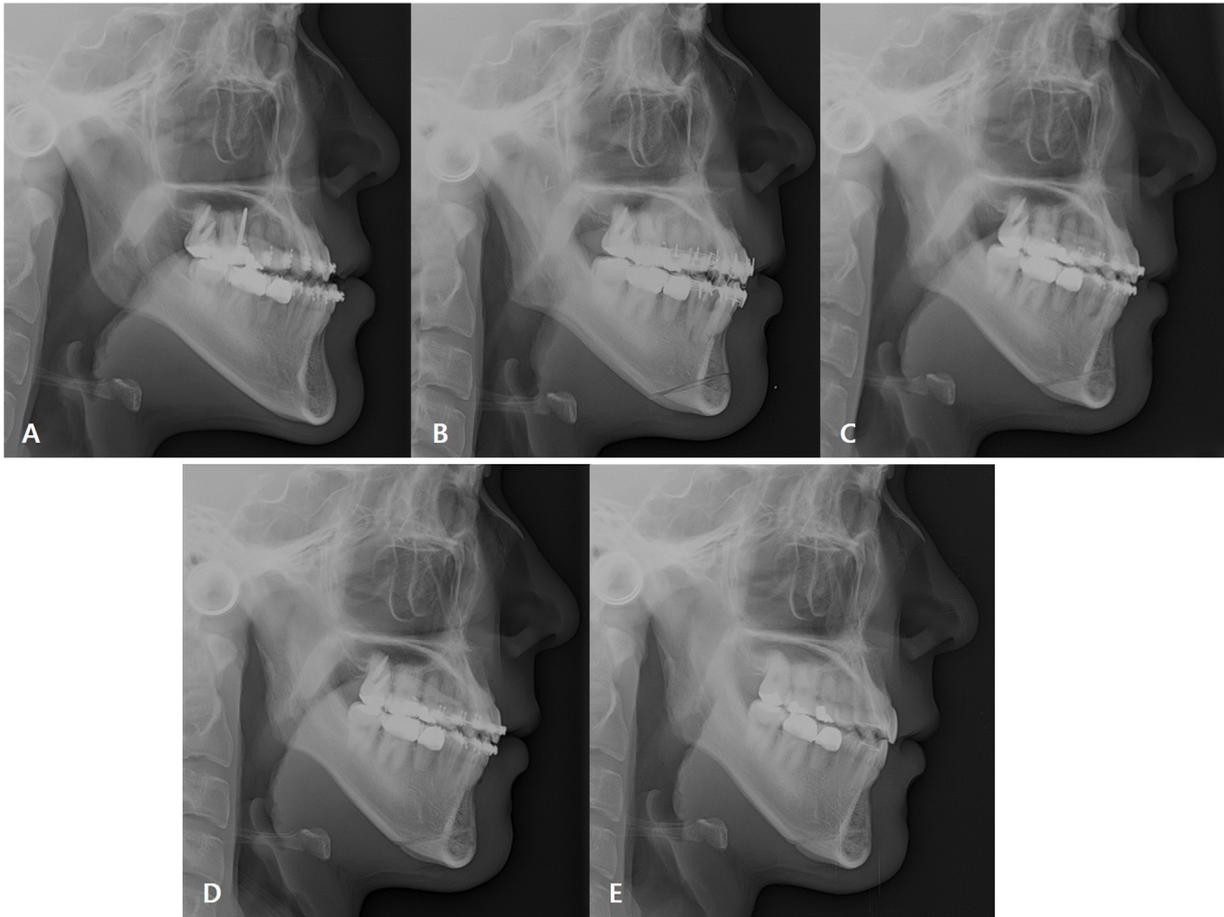


Fig. 2. Serial lateral cephalographs of the same patient. Patient who underwent bimaxillary orthognathic surgery and genioplasty. Maxilla: Lefort 1 osteotomy; Mandible: BIVRO; Chin: vertical height reduction genioplasty. Using a biodegradable plate and screw for maxilla and chin. No fixation on mandibular BIVRO site. We could not find a metal plate and screw with cephalographs. (A) Preoperation. (B) Immediately postoperation. Postoperative swelling on chin area. (C) Three months postoperation. Swelling subsided on chin area. (D) Six months postoperation. (E) Twelve months postoperation. Genial segment and soft tissue were well stabilized.

Table 2. Statistical result of hard and soft tissue changes at 12 months after vertical height reduction genioplasty.

Mean difference			SD	R		
			0.95	0.548 (P = 0.000 ^{***})		
Dependent	Independent	B	Intercept	SE	t	P
cVSM	cVHM	0.590	0.885	0.146	4.036	0.000 ^{***}

cVHM, change in vertical position of hard tissue menton, 12 month after VHRG; cVSM, change in vertical position of the soft tissue menton, 12 months after VHRG; SD, standard deviation; SE, standard error; VHRG, vertical height reduction genioplasty.

^{***} P < 0.001, Pearson's correlation coefficient, Simple regression analysis.

of the maxilla, as well as the vertical stability of the anterior maxilla, were confirmed⁸. The results of this study show that the VHRG using biodegradable fixation was stable in hard tissues immediately after surgery, and in soft tissues 3 months after surgery. The difference between the status of the soft tissues immediately after surgery and 3 months after surgery was probably to be due to the swelling caused by the operation. There were no complications, such as plate exposure, or inflammation, associated with the biodegradable plate in this study. The reason for this was

thought to be because a 1-mm thin plate was used and because the chin is a relatively weak external force site.

There have been few studies regarding vertical changes in the chin after VHRG. Moragas et al. reported that there were seven studies of VHRG from 1976 to 2014; taken together, these studies showed that Me (menton): sMe (soft tissue menton) exhibited an average vertical ratio of 1:0.43²⁶. Among the above studies, only the impaction of the bone fragment was performed in most of them, with the exception of advancement, setback, shaving,

and narrowing of the bone fragments, which were performed by Krekamanov and Kahnberg¹⁷ and Ho et al.¹⁵ Krekamanov and Kahnberg reported that Pog_s (soft tissue pogonion) movement in a superior direction was equal to the vertical reduction of the segment in 19 patients, and that there was no study associated with the location of Me¹⁷. Ho et al. found that the ratio of change in hard tissue to soft tissue was 1:0.35 in Me. However, there was a limited number of 16 patients; thus, the results were statistically insignificant¹⁵.

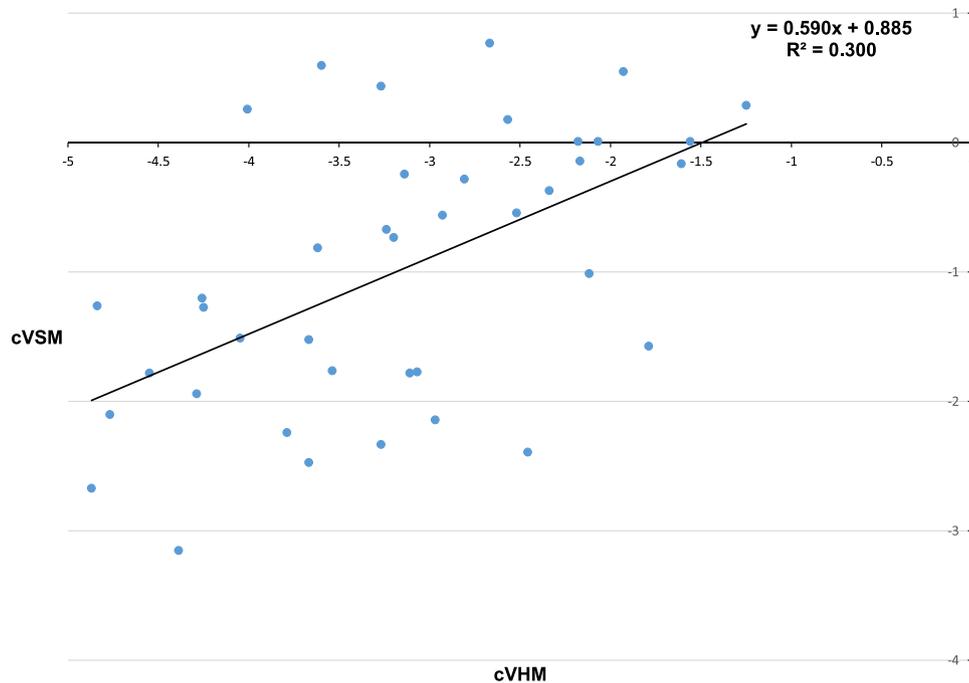


Fig. 3. Scattergram of hard and soft tissue change at 12 months after vertical height reduction genioplasty. cVHM, change of vertical position of hard tissue menton, 12 months after VHRG; cVSM, change of vertical position of the soft tissue menton, 12 months after VHRG. Regression equation: $y = 0.590x + 0.885$, $R^2 = 0.300$, $P < 0.001$.

In this study, we found that changes of chin soft tissues in 40 patients were associated with changes of chin hard tissues, with a statistically moderate positive correlation (Pearson coefficient: 0.540; $P < 0.001$). A corresponding regression equation, $y = 0.590x + 0.885$ ($R^2 = 0.300$, $P < 0.001$), was obtained by simple regression analysis. We compared the preop–12 M VHM change with the regression equation and the actual preop–12 M VSM change in 40 cases of this study. The difference between the two values was mean 0.68 mm (SD = 0.54), and the differences were less than 1 mm (30/40), less than 0.5 mm (20/40), and less than 0.1 mm (5/40).

When VHRG was compared with other types of genioplasty, the change in VSM did not reflect the change in VHM completely. We thought that this might have been because of the muscle groups of the chin, the laxity of the chin soft tissue, and the mandibular setback surgery. In muscles, such as the platysma, digastric, mylohyoid, geniohyoid, and stylohyoid muscles, which are located under the chin²⁷, upward movement of the bone fragment of the chin results in increased tension. Therefore, it seems that the skin and subcutaneous tissue above the muscles do not move upward sufficiently, but remain below the chin, which is not reflected in the amount of movement of the bone fragment of the chin.

Additionally, soft tissue laxity of the soft tissue below the mandible may be involved. The mandibular setback surgery with concomitant genioplasty may employ a situation in which the soft tissues below the mandible must be present in the reduced space, as the space below the mandible decreases. The soft tissue of the chin seems to be insufficient to reflect the movement of the bone fragment, even if the bone fragment is moved upward due to the drooling of the soft tissue. In this study, it was confirmed that the soft tissue of the chin increased slightly (0.01–0.77 mm), even though the bone fragment was positioned upwards in some patients. However, there is no existing study regarding the correlation between mandibular setback surgery and the soft tissue laxity under the mandible. Therefore, further studies related to this aspect are needed.

In conclusion, we confirmed that biodegradable material serves as a stable fixation method that can be used for VHRG. We further concluded that there is a statistical relationship between changes in the hard and soft tissues of the vertical change, after VHRG combined with mandibular setback surgery. In VHRG combined with mandibular setback surgery, soft tissue does not reflect 100% of the amount of vertical tissue reduction in hard tissues. It is thus necessary to establish surgical treatment objectives including consideration of this point.

Financial disclosure statement

No competing interests declared.

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Competing interests

None declared.

Ethical approval

The study was conducted according to the dictates of the Declaration of Helsinki and was approved by the Ethical Review Board of Yonsei University Dental Hospital Institutional Review Board (IRB No. 2-2017-0039). Informed consent was waived due to the retrospective nature of the study.

Patient consent

Not required.

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