

Article

Spontaneous Bone Regeneration after Enucleation of Mandibular Cysts: Retrospective Analysis of the Volumetric Increase with a Full-3D Measurement Protocol

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Featured Application: Evaluation of 3D volumetric bone regeneration previous to implant rehabilitation.



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Abstract: The goal of surgical treatment of mandibular cysts is their eradication. This result can be achieved by ensuring minimum risk of morbidity, while preserving the integrity of the bone structure and the functionality of the inferior alveolar nerve. The generation of bone defects after enucleation has always posed the dilemma of using filler materials or not. The aim of this study is to evaluate the degree of spontaneous bone regeneration, in terms of volume, in patients undergoing enucleation of mandibular cysts, measuring the real 3D volume of the cystic residual cavities. We included in our study 15 patients with mandibular cysts, treated from January 2018 to June 2020 at the Policlinico-Vittorio Emanuele and Policlinico-San Marco hospital of Catania and evaluated preoperatively (T0), 6 months after surgery (T1), and 12 months after surgery (T2). The results showed that after 6 months, independent of the initial volume of the cyst, around 90% of the cavity was filled with new generated bone. In conclusion, we believe that the full-3D measurement protocol can help us to understand the timing and modality of bone restoration after mandibular cyst enucleation.

Keywords: oral surgery; bone regeneration; 3D analysis; mandibular cysts; tissue engineering; oral maxillo facial surgery; odontogenic cyst

1. Introduction

Odontogenic cysts derive from the odontogenic epithelium and develop inside the maxillary bones in correspondence with the dental elements; the proliferation and/or degeneration of this epithelium is believed to result in the development of these cysts [1]. Clinical signs and symptoms related to mandibular cystic lesions may be various, and some lesions, although benign, may involve tooth displacement or root resorption, have a high rate of recurrence, and cause pain or paraesthesia; therefore, it is important to perform a correct diagnosis for adequate treatment [2]. The diagnosis of maxillary lesions is based on the different clinical and radiological characteristics, although the final diagnosis is based on histopathological examination [2]. The goal of surgical treatment of mandibular cysts is their eradication. This result can be achieved by ensuring minimum risk of morbidity, while preserving the integrity of the bone structure and the functionality of the inferior alveolar nerve (IAN) [3]. Various techniques have been described for the treatment of patients with maxillary cysts; however, the choice of adequate treatment remains a controversial topic [4]. Traditionally, the enucleation of odontogenic cysts has been the standard method

of treatment. The enucleation of cysts directly involves the removal of the cystic walls; other commonly used techniques are marsupialization, which connects to the surrounding oral mucous membranes, and decompression, which tries to form bone by relieving pressure in the lesion [5,6]. In choosing the most suitable treatment, surgeons consider the size, location, pathological diagnosis, and anatomical structures of the lesions [7]. If indeed the injury invades adjacent structures, or if primary enucleation involved pathological fracture or neurological damage, marsupialization or decompression are initially considered [7]. The generation of bone defects after enucleation has always posed the dilemma of using filler materials or not. Several authors have suggested factors that lead to graft failure at the same time as enucleation [8]. Failure of this graft could be favored by factors such as smoking, preoperative infection, large cyst, third molar inclusion, peri-wound osteosclerosis, and the use of non-autogenous and autogenous mixed bone [8]. There have been different studies conducted over the years that have evaluated the degree of bone regeneration by measuring the maximum diameters of the residual cavities at intervals of time from the enucleation of the cysts [9]. In these papers it was reported that complete bone healing occurred in all patients 12 and 24 months after surgery [9]. However, the patients were not treated with the same surgical technique (for example, two-stage decompression and then enucleation vs. primary enucleation). Cystic decompression has been introduced in the conservative treatment of odontogenic cysts; there have been multiple cases of decompression treatment and a high success rate has been reported in various studies [10]. Furthermore, imaging follow-up was mainly carried out using OPG [9]. Various studies in the past have used panoramic radiography to evaluate volumetric changes in cysts. Certainly with panoramic radiography, patients are less exposed to radiation; however, it is a two-dimensional analysis method, so it is less accurate in determining the exact volumetric variations [10]. Volumetric studies on the bone regeneration of cystic cavities were conducted by measuring the three maximum diameters and calculating a geometrical approximated volume [11]. The aim of this study is to evaluate the degree of spontaneous bone regeneration, in terms of volume, in patients undergoing enucleation of mandibular cysts, by measuring the real 3D volume of the cystic residual cavities.

2. Materials and Methods

We included in our study 15 patients with mandibular cysts, treated from January 2018 to June 2020 at the Policlinico-Vittorio Emanuele and Policlinico-San Marco hospital of Catania. We selected patients with homogeneous characteristics in terms of the histological nature of the cysts (radicular cysts). The preoperative and follow-up imaging data were CT scans at 6 and 12 months after surgery. We performed volumetric measurements of the cystic cavities on a preoperative CT scan and follow-up CT scans. All patients were treated by the same surgical team, using the same surgical technique and without the use of synthetic or natural filling materials. The preoperative CT DICOM files were uploaded in Horos software (HorosTM, © The Horos Project & OsiriX Team 2020, Annapolis, MD, USA), and we measured the area of the cysts in the individual sections and generated the actual volume of the cysts, before surgery (T0) (Figure 1).

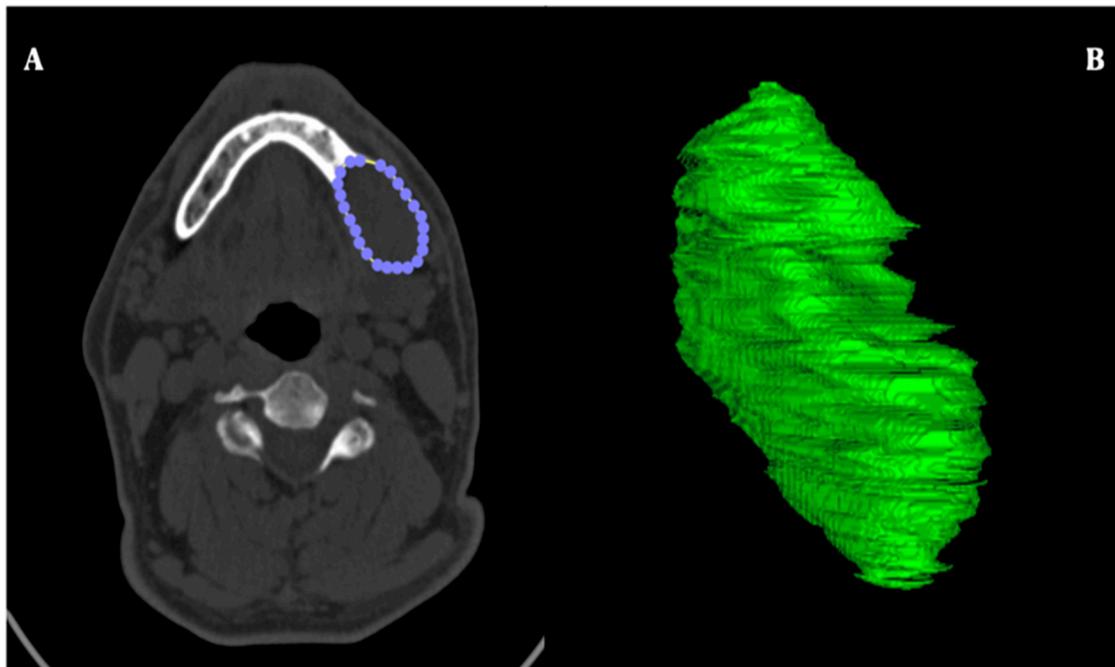


Figure 1. Slice-per-slice volumetric evaluation. (A): Slice perimetral delimitation. (B): Final volumetric rendering.

In the same way, the measurement and volumetric evaluation procedure on the residual bone cavity was performed on the DICOM files of the CT scans performed at 6 (T1) and 12 months (T2) after surgery (Figure 2).

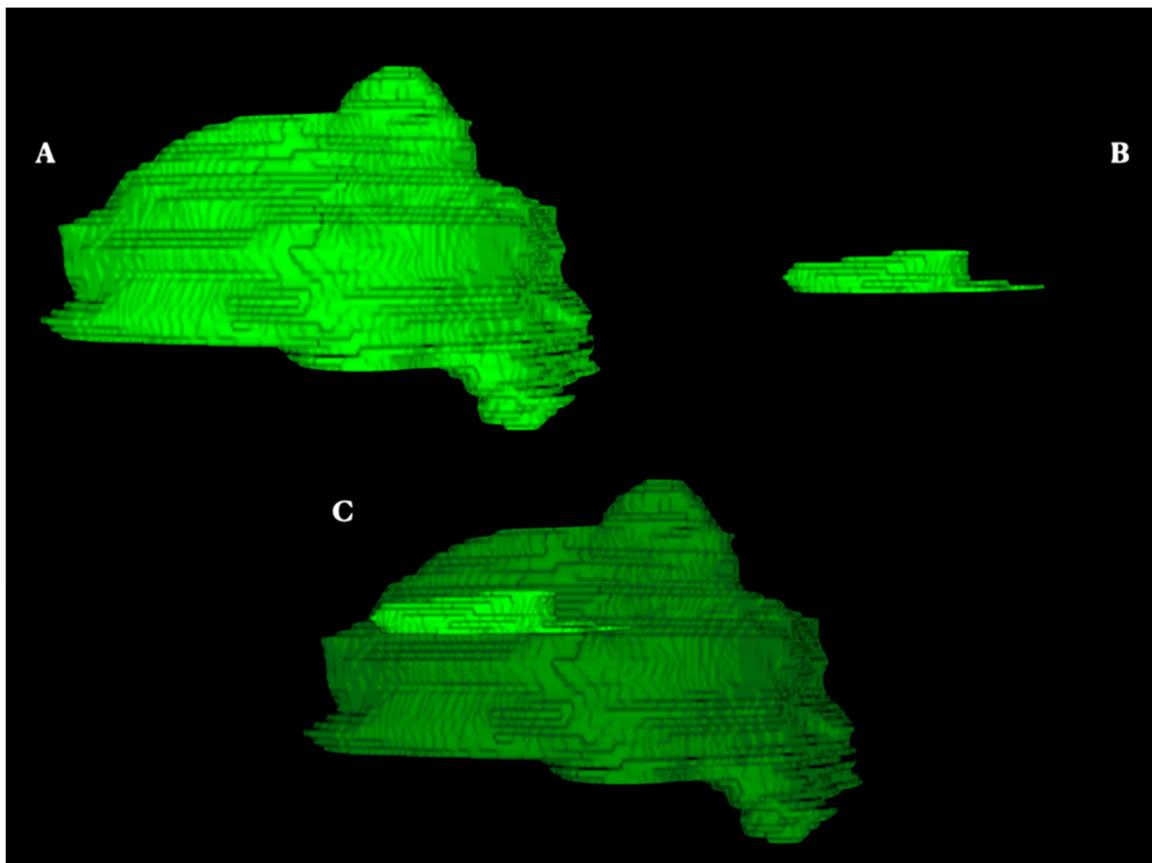


Figure 2. Volumetric evaluation of the cyst. (A): T0 volume; (B): T1 volume; (C): Superimposition of the T0 and T1 volumes.

3. Results

We enrolled 15 patients, 10 male and 5 female patients, with an average age of 43 years (range 24–64). As for the location, four cysts were located in the angle-ramus, five in the body, one in the symphysis, one in the ramus, and four in the body-ramus (see Table 1 for the study population). The surgical approach involved enucleation of the entire cyst with any impacted teeth and curettage of the residual bone surface, using the rotary cutter or piezo-surgery, without the use of filling materials. All cysts were analyzed and tested positive for follicular cysts. All patients took antibiotic therapy with amoxicillin and clavulanic acid for a period of between 7 and 10 days and steroid therapy in relation to the postsurgical edema status. In all cases there were no postoperative infections or abscesses, jaw fractures, or relapses. The results, summarized in Table 2, showed that the average T0 volume was 11.82 cc (range 1.26–19.50 cc). The average T1 volume was 1.49 cc (range 0.07–6.46 cc), with an average residual volume of 10.5% (range 0.37–33.13%). After 12 months, the average residual volume was 0.05 cc, corresponding to an average residual volume proportion of 0.28% (range 0–3.57%) (Figure 3).

Table 1. Mandibular cyst localization.

Site	Patients
Ramus	1
Body	5
Angle/Ramus	4
Body/Ramus	4
Symphysis	1

Table 2. Volume measurements at T0, T1, and T2.

#	Mandibular Site	T0 Volume (cc)	T1 Volume (cc)	T2 Volume (cc)	6 Months Residual Volume (%)	12 Months Residual Volume (%)
1	Angle-Ramus dx	5.15	0.07	0	1.35	0
2	Angle-Ramus sn	12.4	0.12	0	0.97	0
3	Angle-Ramus dx	13.49	4.04	0	29.95	0
4	Body sn	2.20	0.73	0	33.18	0
5	Body dx	2.65	0.11	0	4.11	0
6	Body dx	5.94	0.68	0	11.45	0
7	Symphysis	10.34	2.15	0.37	20.7	3.57
8	Body sn	1.94	0.27	0	13.92	0
9	Ramus sn	12.67	1.03	0	8.13	0
10	Body sn	1.26	0.06	0	4.76	0
11	Body-Ramus dx	16.33	3.26	0	19.96	0
12	Body-Ramus sn	19.50	6.46	0.45	33.13	2.31
13	Body-Ramus sx	13.26	2.34	0	17.6	0
14	Angle-Ramus dx	15.44	2.18	0	14.1	0
15	Body-Ramus sn	8.21	0.81	0	9.87	0

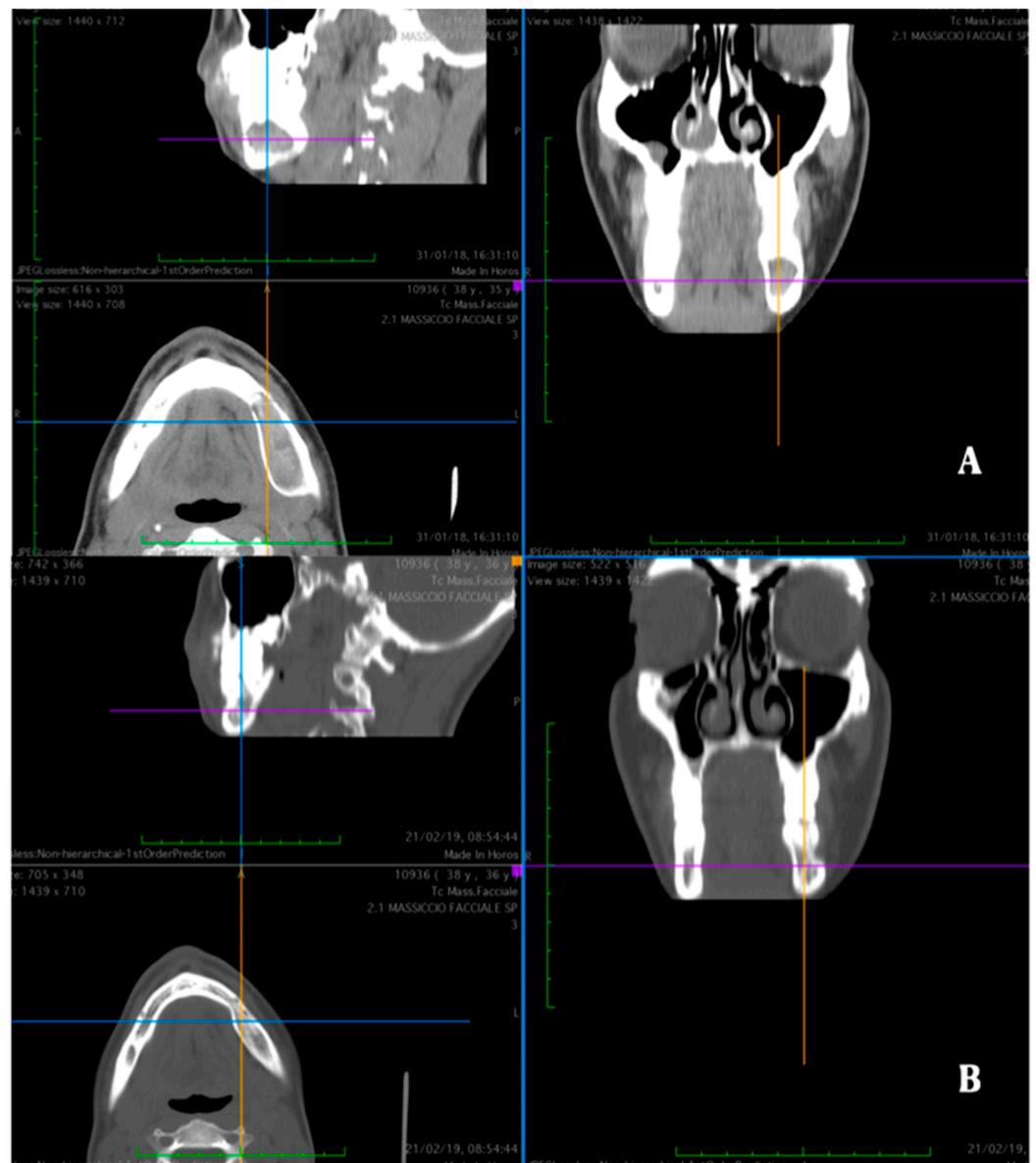


Figure 3. CT scan evaluation of the bone regeneration of a complete case. (A): T0 volume; (B): T2 volume.

4. Discussion

Odontogenic cysts are one of the most frequent pathologies in maxillofacial surgery. The proliferation and/or degeneration of the odontogenic epithelium is believed to result in the development and volume increase of these cysts. The goal of surgical treatment of mandibular cysts is, of course, surgical enucleation, preserving some anatomical structures that may be in intimate contact with the cysts, such as the IAN. Various techniques have been described in order to achieve the final surgical goal of complete enucleation of the cyst. However, although the enucleation of odontogenic cysts has been the standard method of treatment, other commonly used techniques are marsupialization and decompression, which can be considered in the approach to very large cysts. Whichever is the final treatment choice, bone defects after enucleation are always generated, and surgeons must decide whether or not to use filler materials. Lim et al. [8], in a 2017 paper, confirmed that using bone grafts at the same time as surgical enucleation has a high failure rate, due also to factors that worsen this failure rate, such as the use of non-autogenous and autogenous mixed bone. It has recently been acknowledged that surgical enucleation of the cyst is followed by better healing without the placement of a bone graft or other filling materials. However, in terms of bone regeneration and time length, there is still no consensus. In

fact, many studies conducted over the years have evaluated the quantity of regenerated bone by measuring the maximum diameters of the residual cavities after cyst ablation. Rabin et al. [9] reported that complete bone healing occurred in all patients of their series between 12 and 24 months after surgery. However, some issues with the surgical sample can be assessed: the patients were not treated with the same surgical technique, and the residual cavity evaluation was performed on OPG, with bidimensional issues related to this imaging assessment, although patients are less exposed to radiation. OPG is a two-dimensional analysis method, so it is less accurate in determining the exact volumetric variations, as reported by Kwon et al. [10]. For this reason, volumetric studies on bone regeneration of cystic cavities were carried out in recent years, using CT scanning and measuring the three maximum diameters of the cavity. In this way, a geometrical approximated volume can be calculated [11]. Nonetheless, it is still an approximated volume, not a real volumetric measurement. Moreover, in such papers, it was not reported whether or when the bone restoration was completed. In this scientific context, we developed our study to assess how much bone is restored after cystic ablation and how soon, performing on the CT scan a slice-by-slice measurement, achieving a real volumetric analysis for the first time in the literature to the best of our knowledge. Analyzing the individual cases, the greatest residual volume at both 6 months and 12 months was found for the larger cysts, as expected. However, the results of our measurements, carried out on a homogeneous sample of patients, showed that after 6 months, independent of the initial volume of the cyst, around 90% of the cavity was filled with new generated bone. In addition, in all cases, we reached bone restoration of 99.72% at 12 months after surgery. The bone regeneration of our sample suggested that the healing of the cystic cavity does not follow a linear trend, but proceeds exponentially in the first 6 months, whereas the following 6 months consist of a slower filling of the residual cavity and bone remodeling processes (Figure 4). In all cases, the bone regeneration followed a caudo-cranial and centripetal path, as normally occurs for bone regeneration. For this reason, in cases with no or small alterations of the vestibular or, rarely, lingual cortex, the bone width was fully restored. In cases with major cortical loss, the mandibular profile was altered. However, in terms of potential implant rehabilitation, the width reduction was not significant enough to impair further procedures. The same results were encountered for bone height. When teeth were present, no height reduction was encountered. In the case of tooth loss or previous absence, a nonsignificant bone height loss was assessed. This is crucial to consider in all cases going through dental implant rehabilitation, so that surgeons can perform a **“bone regeneration timing”-guided implant surgery**.

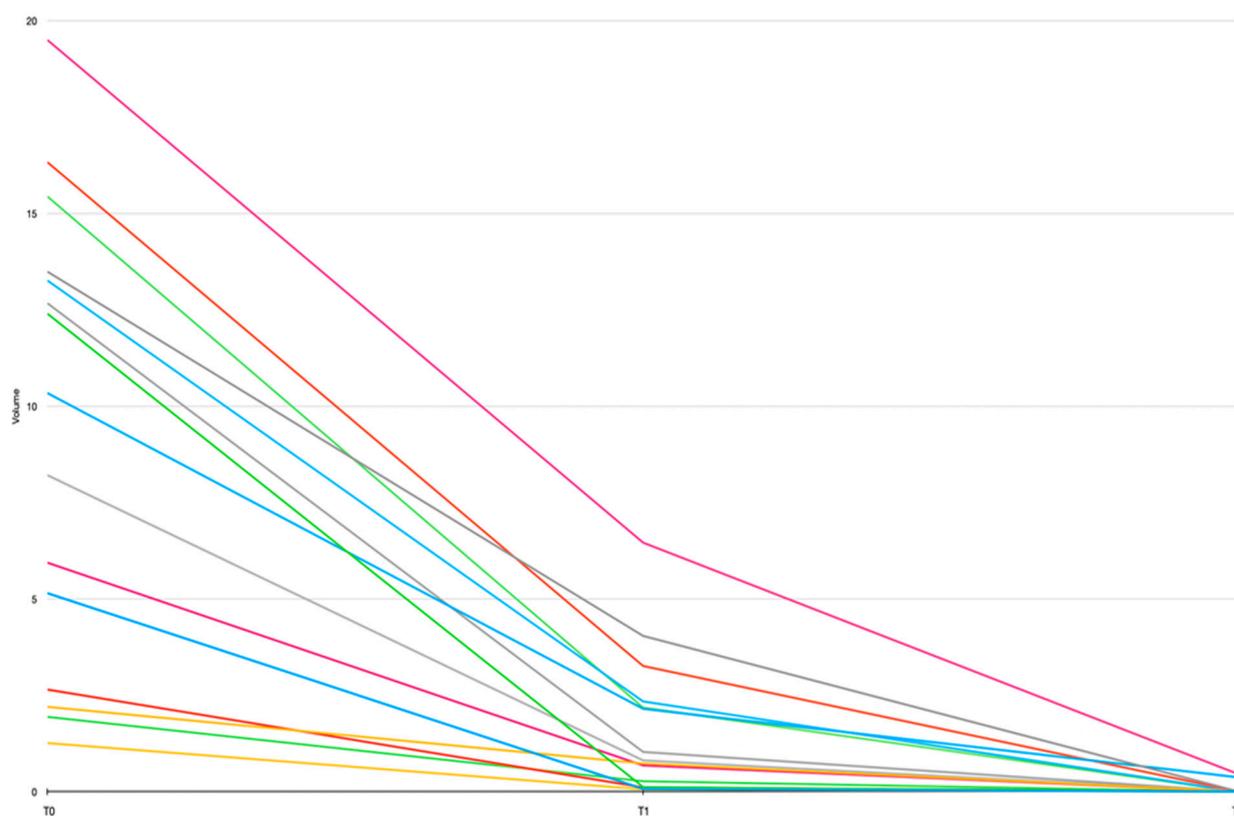


Figure 4. Bone regeneration trends.

5. Conclusions

In conclusion, we believe that the full-3D measurement protocol can help us to understand the timing and modality of bone restoration after mandibular cyst enucleation. Considering the limited sample number but its good representativity of the mandibular cyst population, we can affirm that after 6 months, viable bone stability and restoration can be assumed in patients who have undergone mandibular cyst ablative surgery.

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