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Healing of donor defect after mandibular parasymphyseal block harvesting: A 6-year computerized tomographic follow-up☆

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ABSTRACT

Objectives: A long-term survey on the healing potential of large-sized parasymphyseal osseous defects.
Patients and methods: Ten patients, subjected to 14 bilateral and 3 unilateral parasymphyseal bone harvesting for alveolar ridge augmentation, were selected for the retrospective chart review. CT scans were performed immediately before bone grafting, before implant insertion, and then once annually for 6 years, and the volumes of the bone defects at the buccal aspect in the healing process were measured using a software program. Volumes from the yearly measurements were then compared statistically.
Results: Volumes of both the intrasurgical defects, 0.77 (0.20) cc and of those in the one-year group, 0.60 (0.26) cc were statistically different from volumes of all the other time intervals (from 24 to 72 months) with all p-values less than 0.002 and 0.004, respectively. The healing of osseous defects in the long-term radiographic survey (6 years) resulted in bony infill of 63%.
Conclusion: For parasymphyseal defects of 0.7 cc, a maximum possible healing of two-thirds can be expected; a re-harvesting procedure could be performed 24 months after early surgery, due to both the formation of a new buccal cortical plate and the achievement of a steady state of osseous remodelling.

1. Introduction

Bony defects resulting from infection, trauma, pathology and oncologic resections can be restored using several surgical procedures. In gold-standard grafting strategies, for extensive bone injuries, a matrix or scaffold should support an autogenous bone graft (Motoki and Mulliken, 1990), whereas, for small size defects, local bone restoration was achieved equally well by distraction osteogenesis (Mommaerts et al., 2005; Adolphs et al., 2009) or tissue regeneration techniques (Fischer et al., 2011).

If an autogenous graft was required, a popular extra-oral site for the harvesting procedure was the iliac crest (Eufinger and Leppänen, 2000; Huemer et al., 2004), while a less frequent harvesting site was the calvarium (Cuesta Gil et al., 2010); alternative intraoral sources were the mandibular ramus (Kosaka et al., 2004; Acocella et al., 2010) or the symphyseal area (Kosaka et al., 2004). The mandibular symphysis is a surgical site from which autogenous bone can be harvested easily; among the advantages provided by the symphysis donor site are the possibility of obtaining highly-dense cortical grafts of intramembranous origin and a high level of patient compliance (Misch, 1997; Kosaka et al., 2004).

In a recently published study (Schwartz-Arad and Levin, 2009) revisited symphyseal donor sites for additional bone-block augmentation and a description of how bone defects resulting from a previous harvesting procedure were filled with different materials in order to both permit a more complete recovery of pristine buccal aspect and to increase the re-harvesting potential has also been given. (Schwartz-Arad and Levin, 2009; Dik et al., 2010).

Both short-term and long-term neurosensory disturbances following chin bone harvesting procedures, including alteration in

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lip and pulp sensitivity, have been described in several studies (Nkenke et al., 2001; von Arx et al., 2005; Sbordone et al., 2009; Weibull et al., 2009), although no long-term evaluation of defect healing has been clearly stated (Verdugo et al., 2010): in one recent paper, the size- and time-dependence of the healing of the donor-site defect was described: long healing times were required for large defects (>0.5 cc), but minimal defects (<0.5 cc) were followed-up for a sufficient healing period (average of 34.2 mos), giving a mean of 81% bone fill (Verdugo et al., 2010).

The purpose of the present study is to evaluate long-term donor-site bone fill in following parasymphyseal bone harvesting procedures. Pre- and post-surgical computerized tomography (CT) scans were used to compare the physiological bone fill over time (annually, for 6 years) to determine the minimum time in which the maximum percent of bone fill can be expected.

2. Materials and methods

A retrospective chart review of patients subjected to chin bone harvesting for alveolar ridge augmentation for implant placement was conducted; patients, treated from January 2002 to December 2004, were enrolled in the study. Patients enrolled showed progressing maxillo-mandibular atrophy resulting from either tooth loss and alveolar bone remodelling or maxillary sinus hyperpneumatization in edentulous sites. Patients requiring further osseous reconstruction were subjected to a subsequent extra-oral harvesting procedure (iliac crest). No patient had received bone resection as part of oncological treatment.

Records were reviewed to gather pertinent information regarding the number and location of harvesting procedures, adjunctive surgical procedures, surgical treatment outcomes and the numbers and time-points of CT scans. Age (years), sex and smoking habits of patients were also recorded. Patients who underwent a parasymphyseal bone harvesting procedure, confined to the symphyseal area, were included in the study. Patients without annual maxillo-mandibular CT scans for72 months post operatively were excluded from the study.

2.1. Surgical methods

Patient suitability for parasymphyseal harvesting procedure was assessed by preoperative CT scans. All surgery was performed under general anaesthesia. 2% mepivacaine with epinephrine (20 mg/ml + 12.5 mg/ml) was administered locally to reduce bleeding. One or two blocks, depending on need, were harvested from the parasymphyseal area, according to the procedure described by Balaji, (2002), but using a horizontal mucosal incision 5 mm apical to the muco-gingival junction. No material was used to fill the residual defect in the donor area.

The lower margin of the mandible was preserved to avoid altering the chin contour (Fig. 1A). All patients received amoxicillin and clavulanic acid (2 g/i.v. 1 h preoperatively, and subsequently

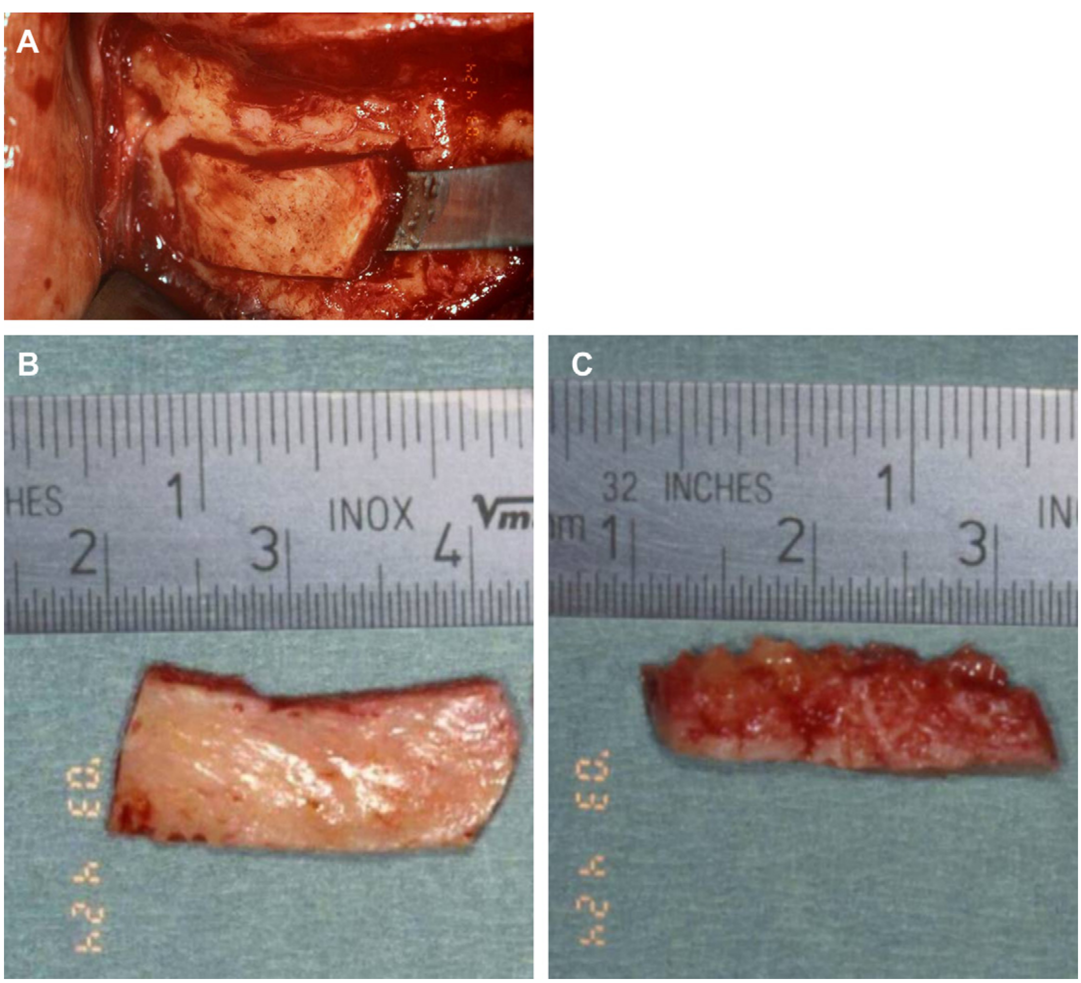

Fig. 1. Patient #1: bilateral mandibular parasymphyseal bone-block harvesting sites with osteotomy lines (A); one-piece parasymphyseal block graft in buccal view (B) and in sagittal view (C).

1 g b.i.d. i.v. or p.o. for 7 days) and a 0.12% chlorhexidine rinse (b.i.d. for 2 weeks). Post-operative pain was controlled by i.v. administration of ketorolac 90 mg + tramadol 200 mg over 24 h through an elastomer device. In all cases, titanium dental implants were inserted into the grafted areas 3–6 months after the reconstructive stage.

2.2. Variables and data collection

As part of the standard treatment protocol, patients had CT scans (High Speed double detector CT scanner, General Electric Medical System, Milwaukee, WI, USA) taken immediately before bone grafting, 3–6 months after the graft (Sethi and Kaus, 2001) just before implant insertion, and then 12 months after implant insertion. For further maxillo-mandibular atrophy requiring further osseous reconstructions, standard CT scans (immediately before bone grafting, 3–6 months after the graft and 12 months after implant insertion) were acquired.

Tomographic CT scan data were imported into a software program, and pre- and post-operative axial images were superimposed (†† Image Processing Toolbox, MatLab 7.0.1, The MathWorks, Natick, MA) (Fig. 2). Measurements of the volume of bone defects at the buccal aspect in the healing process were taken using axial CT slices with a thickness of 1 mm: measurements were performed with SimPlant Pro 12.02 (Fig. 2), (Materialise Dental Italia. Via L. Fincati 13/f, 00154 Roma, Italy), according to Smolka et al. (2006).

Data relating to the linear dimension of each harvested parasymphyseal block graft (length, height and thickness) were measured intrasurgically using standard surgical calliper or ruler by the same calibrated examiner (LS) (Fig. 1B); intrasurgical block volumes were extrapolated by linear measurements as described by Verdugo et al. (2010).

Results were ranked according to the timing of CT scans at six time intervals: T_1 (0–12 mos), T_2 (13–24 mos), T_3 (25–36 mos), T_4 (37–48 mos), T_5 (49–60 mos), T_6 (61–72 mos), where time T_0 represented the time of intrasurgical measurements. Measurements of the volume of bone defects at the buccal aspect (V_1, V_2, V_3, V_4, V_5 and V_6) were compared to the intrasurgical block volume (V_0) to determine the percentage of bone fill. Percentages were rounded to the nearest 0.5%.

2.3. Statistical analysis

All patient-related data were entered into a database (Access, Microsoft Corp, Redmond, WA), allowing calculations to be performed automatically. Descriptive statistical analyses were performed using a statistical tools package (Statistics Toolbox, MatLab 7.0.1, The MathWorks, Natick, MA).

Normal distribution for each data set was carried out, but not confirmed, by the Lilliefors test for data, forming different follow-up time intervals. The data are assumed to come from a continuous, symmetrical distribution around its median.

All measurements in the text and tables are described as median and interquartile range (difference between 75th and 25th percentiles). In the Figures, distributions have been depicted by box-and-whiskers plot, in which the box line represented the lower quartile, median, and upper quartile values, while the whisker lines included the rest of the data. Outliers were data with values beyond the ends of the whiskers.

In the comparison tests, to overcome the differences between bilateral parasymphyseal harvesting procedures, one defect per patient was randomly selected (Herrmann et al., 2005). Because the measurements obtained are not normally distributed, Wilcoxon matched pairs signed rank tests were used to assess the changes between times. The level of statistical significance was set at .05 for all analyses.

3. Results

Fourteen bilateral and three unilateral mandibular parasymphyseal harvesting areas were measured in 10 patients (3 smokers): 7 males and 3 females, ranging in age from 39 to 58 years [median 50 (14)]. No patient had previous anterior mandibular surgery, and the post-operative clinical course of all sites was uneventful, with all patients being satisfied with their chin profile.

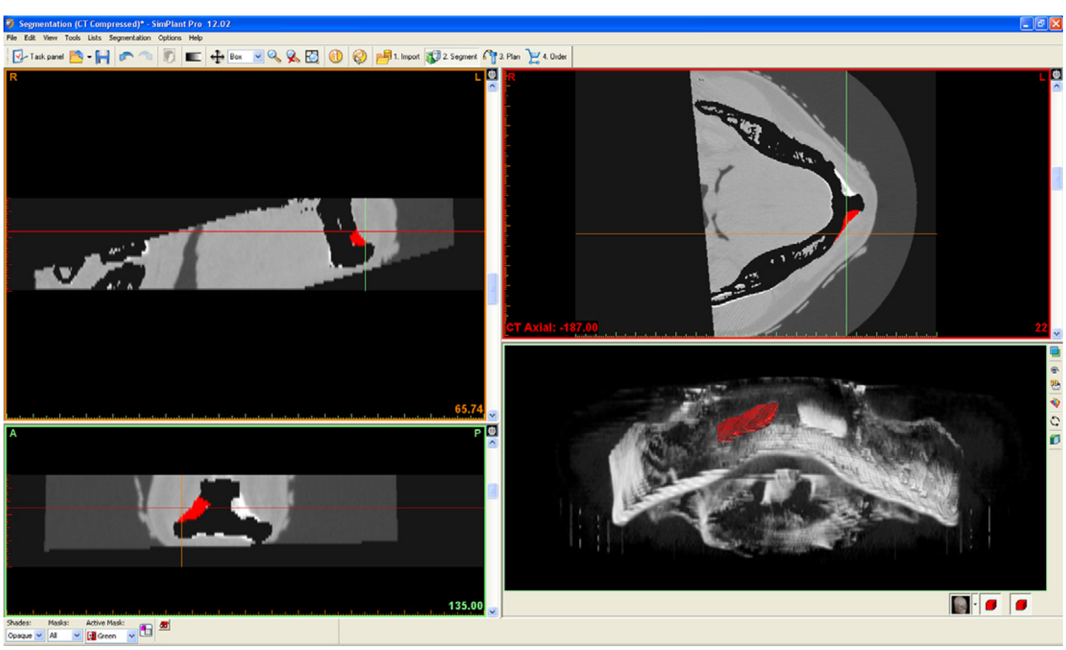

Fig. 2. Patient #1: view of the display of the software program SimPlant Pro 12.02 showing: in axial-, frontal- and sagittal-section the defect with a red active mask. Post-operative data is shown as a black active mask. The defect is shown as a red volume in the 3-D reconstruction.

Table 1 shows the size of the harvested defects and the percent of bone fill at 6-year follow-up. In Fig. 3 the volume distributions of the defects in each follow-up time interval are described by box-and-whiskers plot. Differences at a statistically-significant level were recorded among intrasurgical volumes of defect [at time T_0: 0.77 (0.20) cc] and the volumes of all the other time intervals; of note is that the median of volume defects at first CT scan follow-up [at time T_1: 0.60 (0.26) cc] was statistically different from those of all the other follow-up time intervals (medians and interquartile ranges of V_2, V_3, V_4, V_5 and V_6 were 0.39 (0.18) cc, 0.32 (0.09) cc, 0.25 (0.15) cc, 0.35 (0.21) cc and 0.27 (0.08) cc, respectively). Statistically-significant differences were also recorded among time intervals higher than 18-months of follow-up, but notwithstanding a continuously decreasing trend in defect volumes, results found in the comparisons were variable. Statistical analysis of the percentages of bone fill among times showed results very close to those of volumetric analysis; the median percent of bone fill of the defects at time T_6 was 63 (2). Fig. 4 shows preoperative and post-operative cross-sectional images of parasymphyseal donor site at the cuspid level.

4. Discussion

This paper aims to update information concerning the physiological bone fill of defects resulting from parasymphyseal harvesting procedures for dental implant positioning.

A bony defect is produced as a result of the harvesting surgery. It rapidly moves through a set chain of healing stages, from early vascular proliferation (Reddi et al., 1987) to bone repair with woven bone initially apposed to trabecular surfaces, followed rapidly by lamellar bone deposition (Shapiro, 2008) (Table 2).

Table 1
Descriptive analysis of Data. *Block dimension: length · height · thickness in millimetres (volume in cubic centimetres).

Patient	Age (years)	Gender	Smoking habits	Block Dimension* (cc)	Final % of Bone fill
1	54	F	N	21 × 8 × 5 (0.84)	62
2	42	M	Y	18 × 9 × 5 (0.81)	68
3	49	M	N	16 × 8 × 5 (0.64)	63
4	58	M	N	13 × 9 × 5 (0.585)	69
5	42	M	N	6 × 8 × 4 (0.192)	65
6	56	M	N	15 × 9 × 7 (0.945)	64
7	50	F	Y	17 × 9 × 5 (0.765)	64
8	57	M	Y	19 × 10 × 5 (0.95)	61
9	39	M	N	13 × 8 × 7 (0.728)	63
10	50	F	N	13 × 7 × 6 (0.546)	71

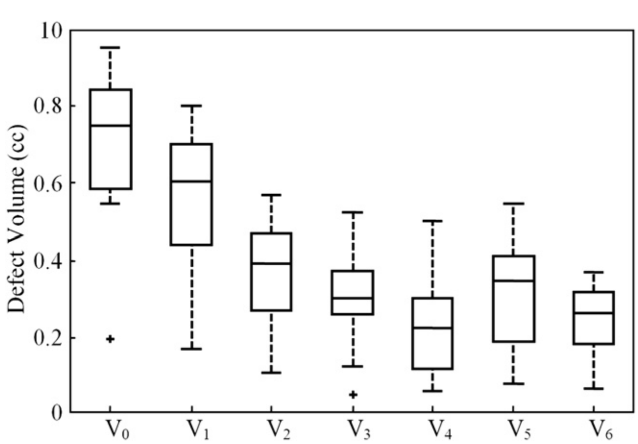

Fig. 3. Box plots for volume measurements expressed in cc among different follow-up times: T_0 (intrasurgical), T_1 (0–12 mos), T_2 (13–24 mos), T_3 (25–36 mos), T_4 (37–48 mos), T_5 (49–60 mos), T_6 (61–72 mos).

Short- and long-term analyses of neurosensory disturbances for bone harvesting procedures in the chin area have been evaluated by several studies in the literature. These studies have shown a substantial reduction in the length of neurosensory side effects (Nkenke et al., 2001; Nkenke et al., 2002; von Arx et al., 2005; Sbordone et al., 2009; Weibull et al., 2009). Among these studies only one described the course of osseous regeneration of the harvesting area in the retromolar region assessed on digital panoramic radiographs. Radiographic analysis of ROIs (regions of interest) covering the areas of bone harvest showed that 6-month post-operative data did not differ from the preoperative data, whereas it showed a significant difference when compared to immediate post-operative data, verifying a probable bone regeneration (Nkenke et al., 2002).

Further research analysed the bone regeneration by means of two-dimensional or volumetric measurements. In a recent study, the donor-site defects and the effects on the soft tissue contours were measured in cephalograms; the presence of a residual defect evident 1 year after harvesting chin bone was recorded, while at the same time an increase in soft tissue thickness, at the donor site, was confirmed. Nevertheless, the two-dimensional analysis of the cephalogram resulted in an underestimation of the residual defect (Dik et al., 2010).

Volumetric analysis of the healing of the external osseous profile of the chin was not performed before chin site revisiting in order to acquire a new bone block for further osseous augmentation (Schwartz-Arad and Levin, 2009): the pristine contour of the mandibular symphysis was restored filling the chin donor site with different bone substitutes (Schwartz-Arad and Levin, 2009; Dik et al., 2010) whose effects must be analysed individually, material by material.

Although the analysis of the harvesting area through two-dimensional analysis (area in cephalograms or ROIs in digital panoramic radiographs) seemed to show a positive course of osseous regeneration (Nkenke et al., 2002; Dik et al., 2010), only volumetric studies could have conclusively verified this issue. If the chin defect was not filled with a bone substitute, thereby requiring physiological healing, a rough volumetric analysis described the long-term healing of defects (average of 34.2 mos) with a size less of 0.5 cc, yielding a result of healing of 81%; the volumetric analysis of defects with a size larger than 0.5 cc showed a repair of 63.8%, but the healing time (7.2 mos) was not sufficient to indicate the timing and the expectation of physiological healing in the long-term (Verdugo et al., 2010).

Patients surveyed in this retrospective study were all subjected to parasymphyseal bone harvesting procedure with symphysis midline preservation. The distribution of volumetric measurements, presented in Fig. 3, showed a continuous reduction of bone defects until 4-years of follow-up, for which V_4 was 0.25 (0.15) cc. Nevertheless, the statistics showed that only volumes measured at time T_0 and volumes included in interval T_1 (0–12 mos) were significantly different from all the others, so the volumetric, physiological, healing of the bone defect seems to be achieved 24 months after harvesting surgery. Note that in Fig. 4 the cross-sectional images of defect at the cuspid level at 17 months show the presence of a new buccal cortical plate. The formation of the cortical plate may have prevented the maximal self-repair potential.

Regarding the percentage of bone fill of the defects, the final value (measured for T_6, 6-year), shown in Table 1, showed that the calculated value of 63% is very similar to that obtained by Verdugo et al. (63.8 ± 12.2%) for defects of the same size but with a very short-term follow-up. Data suggested that in a parasymphyseal

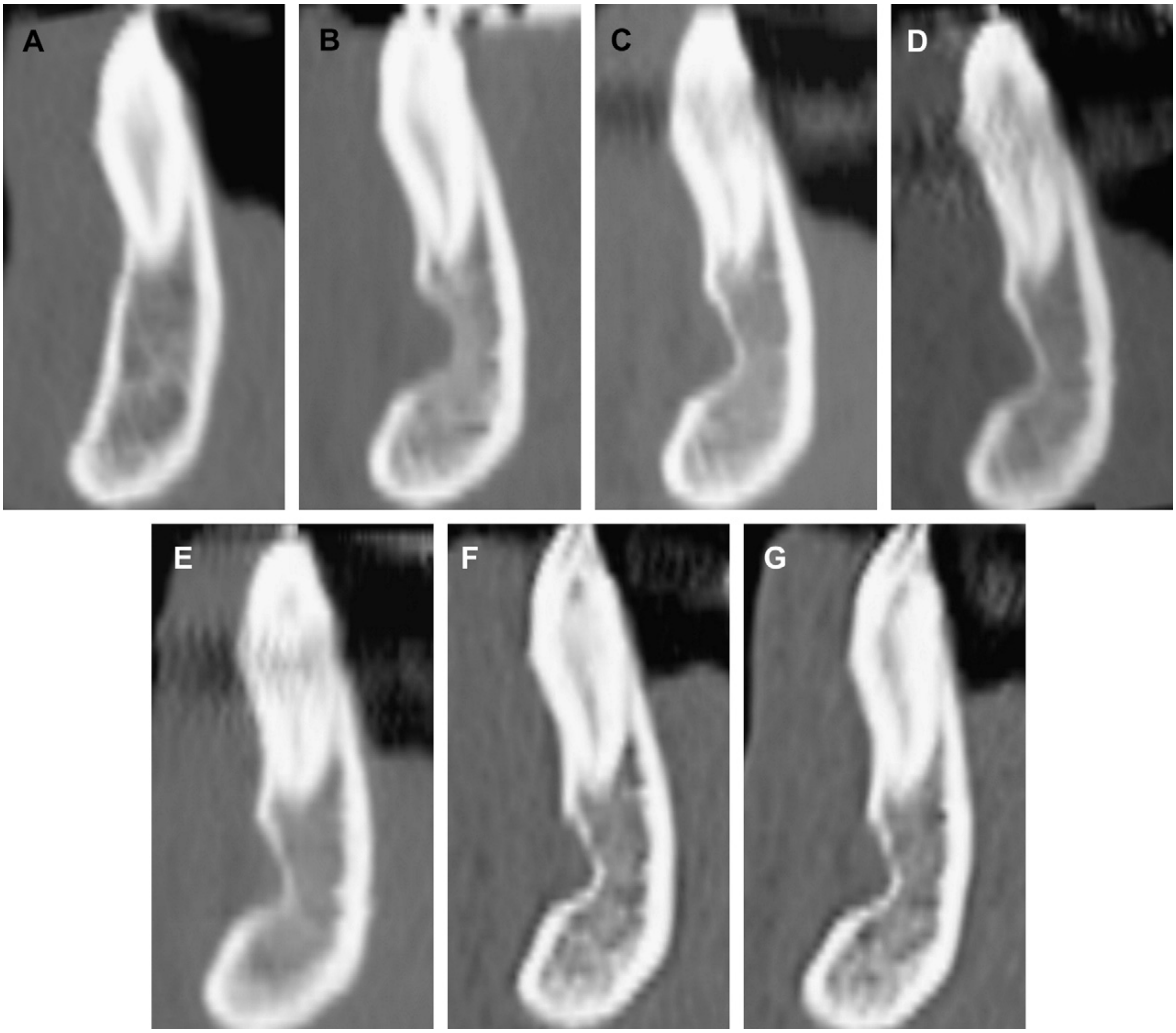

Fig. 4. Preoperative (A) and post-operative cross-sectional images of parasymphyseal donor site after 6 (B), 17 (C), 30 (D), 42 (E), 51 (F), 63 (G) months of healing time in patient #4. Note the achieved formation of a buccal cortical plate in the cross-sectional image at 17 mos (C), and the persistence at 63 mos of 31% of the bone defect resulting from the surgical harvesting procedure (G).

Table 2
Statistical significance analysis; comparing volumetric dimensions of defects among different follow-up time intervals: T_0 (intrasurgical), T_1 (0–12 mos), T_2 (13–24 mos), T_3 (25–36 mos), T_4 (37–48 mos), T_5 (49–60 mos), T_6 (61–72 mos): *significant; NS non-significant. Wilcoxon matched pairs signed rank tests.

	V_0	V_1	V_2	V_3	V_4	V_5
V_6	*	*	*	NS	NS	*
V_5	*	*	NS	NS	*	
V_4	*	*	*	NS		
V_3	*	*	NS			
V_2	*	*				
V_1	*					

defect, with a volume close to 0.7 cc, a maximum healing of two-thirds, and no more, can be expected; a re-harvesting procedure can be performed at 24 months after early surgery due to both the formation of a new buccal cortical plate and the achievement of a steady state of osseous remodelling.

If clinicians plan re-harvesting from the chin, the use of filler material in new parasymphyseal defect might favour bone repair. Further studies should work towards an evaluation of the biological properties of several filler materials, whether their resorbability be of a low, medium or high degree, in order to find the most useful bone substitute for filling procedures in parasymphyseal defects.

5. Conclusions

For large-sized parasymphyseal defects, a maximum possible healing of two-thirds can be expected; a re-harvesting procedure may be performed 24 months after the initial surgery, due to the formation of both a new buccal cortical plate and the achievement of a steady state of osseous remodelling.

Conflict of interest

All authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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