

Case Report

Bone Compactness and Bad Split in the SSO (Sagittal Split Osteotomy) of the Mandible

Carmine Taglialatela Scafati^{1*} and Giuseppe Di Costanzo²

¹Formerly Head of the Maxillofacial Surgery Unit, P.O.S. Maria delle Grazie of Pozzuoli, ASL NA 2 Nord, Italy

²Medical Director of Radiology, P.O.S. Maria delle Grazie of Pozzuoli, ASL NA 2 Nord, Italy

Abstract

Sagittal split osteotomy (SSO) of the mandible is still an important part of orthognathic surgery, but “bad split” fractures that happen during the surgery are still a big problem. This report describes a rare case of bilateral bad split associated with highly compact mandibular bone (D1–D2 type) in a 53-year-old male undergoing mandibular advancement. The bone was too hard for the piezoelectric and rotary tools to work, and there was very little bleeding. This caused fractures in the cortex and lingual. Postoperative computed tomography confirmed the presence of highly dense bone, correlated with delayed healing and recurrence. Consistent pre-surgical CT scanning for an assessment of the density of the mandibular bone can provide essential information about the potential risk of the osteotomy procedure in the patient. Performing a careful bone quality and density examination pre-operatively will allow the surgeons to select the most appropriate instruments and surgical techniques that will fit the patient’s individual anatomy. Such a point escalates to being very significant when dealing with the geriatric population, as bone density increase can not only alter the fracture behavior but also the recovery process during and after surgery. The inclusion of regular CT-based bone density evaluations into the preoperative routine not only facilitates the anticipation of surgical difficulties but also results in safer and more efficient osteotomies.

Introduction

A feared complication in orthognathic surgery is the poor separation of the bone fragments during the sagittal osteotomy of the mandibular branches (SSO), commonly known as “bad split” [1,2]. Anomalous fractures can occur on both the proximal and distal segments. In fractures of the proximal segment, which is the most affected [3-5], there may be a fracture of the condyle, which makes the treatment more complicated, especially when, in the separation of the fragments, it remains attached to the distal fragment [6]. Another occurrence of the bad split is the entrapment of the alveolar nerve in the proximal fragment, which can remain damaged [7]. The bad split, in addition to making fracture reduction and synthesis difficult, can worsen the postoperative course with infections, fistulas, necrosis, and bone sequestra [8-11], which require further treatments. All these situations, even in the mildest forms, do not favor the consolidation of the synthesized bone segments, giving

rise to pseudarthrosis (relapse) [12-14], malocclusion, and temporomandibular dysfunction [9]. In some cases, tracheotomy has been required due to massive edema compressing the airways [11]. Bad split therapy, as for all fractures, uses rigid internal fixation [15], accompanied in many cases by intermaxillary block [16,17]. The percentage of bad splits reported in the literature varies. According to a large study reporting 21 case studies by different authors [8], it varies from 0.95% to 22.72% of all patients.

Regarding the causes of the bad split, numerous works have been published, in which a certain cause has never been identified, suggesting that this may reside in several factors that combine, such as the age of the patient, the presence or absence of the sinus molar, the time elapsed between its extraction and the operation, the anatomy of the mandible, the planning of the operation, the experience of the operating surgeon. As a prevention measure, there are those who suggest the use of separators instead of chisels

More Information

*Address for correspondence:

Carmine Taglialatela Scafati, Formerly Head of the Maxillofacial Surgery Unit of the P.O.S. Maria delle Grazie of Pozzuoli, ASL NA 2 Nord, Italy, Email: carminetaglia@libero.it

Submitted: May 17, 2024

Approved: October 13, 2025

Published: October 14, 2025

How to cite this article:

Scafati CT, Di Costanzo G. Bone Compactness and Bad Split in the SSO (Sagittal Split Osteotomy) of the Mandible. J Oral Health Craniofac Sci. 2025; 10(1): 001-006. Available from: <https://dx.doi.org/10.29328/journal.johcs.1001051>

Copyright license: © 2025 Scafati CT, et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Keywords: Sagittal split osteotomy; Bad split; Mandibular bone density; CT evaluation; D1 bone; Orthognathic surgery



and osteotomes or the use of ultrasound instruments instead of classic ones [3,6,8,18]. There has even been some work that focuses on the usefulness of hitting the osteotome with the hammer once or twice consecutively and on the sequence of osteotomes to be used [19].

In the various etiological hypotheses, no works are reported in the literature that focus on the quality of the bone to be osteotomized, especially in reference to the degree of hardness, which according to the Misch classification, which takes the Hounsfield units as a unit of measurement, varies from D1 type more mineralized and compact, D4 bone, spongy with large intertrabecular gaps. The D2-D3 bone represents intermediate forms [20,21]. Tab 1 (by C. Mish).

D1> 1250 Hounsfield units

D2: 850-1250 Hounsfield units

D3: 350-850 Hounsfield units

D4: < 150 Hounsfield units

Clinical case

53-year-old male patient. He comes to our attention for an Angle class II dentoskeletal class II dentofacial deformity.

For this reason, after the OPT and telecranium x-graphic investigations and the pre-surgical orthodontic treatment, mandibular advancement is planned via osteotomy of the mandibular branches according to Obwegeser Dal Pont [22,23]. The surgery is conducted under general anesthesia. We proceed with corticotomy and partial sagittal osteotomy on the right using the Piezo Surgery Mectron. Buccal and lingual relief osteotomies are performed with Lindmann rotating drills. During the execution of corticotomies and partial osteotomies, despite the depth, there is a clear sensation of a hard, non-bleeding bone both on the right and left. On this last side, after having carefully rounded and freed the corners of the corticotomies with the aid of the Piezo and rotating instruments, we proceed to complete the osteotomy, using thin and sharp osteotomes (chisel). As soon as the osteotomy has begun, there is the unwelcome surprise of a "bad fracture" of the cortex of the proximal segment, with the fracture line which, from above the external oblique line, moves backwards and upwards, towards the semilunar notch of the ramus. Once the integrity of the condylar process has been established, the osteotomy is continued with greater attention and delicacy, but despite this, another fracture of the lingual segment is determined. At this point, realizing that we are faced with a mandibular bone that breaks like glass, we decide to desist from continuing with the operation to avoid further complications such as fracture of the condyle. We then proceed to synthesize the bone fragments with a miniplate with four holes and three bicortical screws. The right side is left with the partial osteotomy, and a rigid intermaxillary block is applied. The wounds are closed with detached stitches in a single layer with absorbable material. A

postoperative control CT with 3D reconstructions highlights the double bad split and the osteosynthesis performed (Figures 1,2). The measurement of bone density reveals a high density of the D1-D2 type (Figure 3).

The piezoelectric system (Mectron Piezosurgery II) was operated at a frequency of 25–30 kHz with irrigation at 60 ml/min using a diamond-coated insert (OT7 tip) for cortical separation. Rotary osteotomies were performed with a Lindemann bur (ISO 170 µm) at 20,000 rpm under copious saline irrigation. The tactile feedback during drilling was notably high-pitched and resistant, confirming extremely mineralized bone with limited medullary compliance. No significant medullary bleeding was observed, corroborating the postoperative CT findings of D1-D2 density [18,24,25].



Figure 1: Intraoperative view showing cortical fracture line during sagittal split osteotomy.



Figure 2: Post-operative radiograph demonstrating double-bundle split and initial fixation.



Figure 3: CT 3D reconstruction showing D1-D2 bone density bilaterally.

The postoperative course, on the tenth day or so, is complicated by an inflammatory process with exposure of the synthesis media, which is followed after another 10-15 days by mobility of the superficial bone fragment, which is also ischemic. With a second operation under local anesthesia assisted by sedation, the mini osteosynthesis plate and a bicortical screw, both loosened, are removed (relapse). The mobile bone fragment, which represents the distal third of the proximal fragment that subtends the coronoid, is removed. We then proceed to close the wound with detached stitches and restore the intermaxillary block. On the ninth day, there is a new dehiscence of the wound, which is treated with daily cleaning and irrigation until it heals by secondary intention. The intermaxillary block remained in place for another four weeks, after which it was removed, with the patient recommended to be on a liquid diet for another 3 weeks. In the following days, the patient does not show up for clinical checks. After about a month, he returned to us complaining of pain and swelling on the left side, where he had marked perimandibular edema. Intra-oral bimanual palpation highlights the mobility of the bone segments, as per malunion of the fracture. A control OPT highlights advanced osteolysis in correspondence with osteosynthesis (Figure 4). The 3.7 is vital to the thermal test.

Figure 4 OPT showing an osteolytic area in region 3.6,3.7,3.8. Note the absence on the left of the bone fragment that supports the coronoid, which is in place.

For this reason, a surgical reoperation is planned under general anesthesia, during which, after having exposed the fracture site, the osteotomy site is washed and curetted. Under the guidance of the occlusion, we proceed with the reduction and double osteosynthesis with 2 mm titanium plates and screws of the bone segments. On the third day, light elastic occlusal guides were applied; the postoperative course was regular. The subsequent checks were regular, and approximately forty days after the operation, the orthodontic appliance was removed. A control CT highlights the good alignment of the fracture stumps and advanced bone healing (Figures 5,6).

The case reported is singular for the refusal to complete the mandibular osteotomies, due to unwanted fractures, both on the proximal and distal bone fragments. This occurrence occurred in the early stages of the use of manual osteotomes (chisel), despite the deep corticotomies carried out with ultrasound and the use of delicate and sharp manual instruments, as well as the maximum attention paid to the execution of the osteotomies [26]. A case of failure to complete SSO is also reported by Mensink due to a large unwanted fracture involving the proximal fragment [6]. In our case, the interruption of the surgical intervention occurred to avoid further fragmentation of the mandibular bone segments, as well as to avoid a possible fracture of the condyle. Despite this, the therapy provided with the rigid internal fixation of



Figure 4: Orthopantomogram revealing osteolytic area and absence of coronoid-supporting fragment.



Figure 5: Post-reoperation CT showing improved alignment of bone stumps.



Figure 6: 3D reconstruction after the second fixation showing advanced healing.

the fragments (FIR) and the intermaxillary block had to be re-operated on two more times, first to remove a necrotic bone fragment, then due to the failure of consolidation of the fracture. The decision not to complete the operation became even more necessary, as it involved mandibular advancement and not retreat, in which, by impacting the bone on itself, it would have been easier to find a free area to carry out osteosynthesis. In the case of a retraction of the mandible as occurs in the third skeletal classes, a vertical osteotomy

of the ramus could be used [6,27]. It was not possible to complete the osteotomies with piezo surgery, as the distance between the crestal margin of the mandibular bone and the lower edge was greater than the length of the piezo surgery insert [28].

Wanting to research the cause of the bad split, the main element highlighted during the surgical procedure was the hardness of the mandibular bone and the lack of bleeding on the cut, once it reached the presumed medulla.

If preoperative CT assessment of bone density were routinely implemented, surgeons could anticipate areas of high resistance and modify the surgical approach accordingly. For instance, in patients demonstrating D1-type bone, it may be advisable to extend corticotomies, reduce chisel force, or rely more heavily on piezoelectric dissection to minimize stress propagation. Additionally, older patients or those with limited marrow spaces should undergo CT to quantify Hounsfield units preoperatively. Such an assessment may influence not only the osteotomy design but also the fixation protocol and postoperative monitoring for delayed union [18,24,25].

The preoperative investigation that would have allowed us to know the hardness of the mandibular bone to be treated is the CT, which was not performed, as it is not part of the routine investigations of orthognathic surgery [24]. CT of the mandible is performed in the preoperative phase by some authors to identify the mandibular canal, evaluate its course, and the distance between it and the buccal cortex to avoid damaging the alveolar nerve during SSO [29,30]. Other authors use CT to obtain 3D images of the mandible, to evaluate its anatomy, plan surgery, and monitor postoperative results [31,32].

In our case, a postoperative control CT exam with 3D reconstructions, in addition to highlighting the unwanted fractures and the osteosynthesis performed, allowed us to measure the hardness of the bone, highlighting an extremely compact bone, which justified, in our opinion, the poor bleeding during osteotomies, the bad split, and probably delayed bone healing.

The postoperative control CT was processed with 3D Volume Rendering (3D VR) and Multiplanar (MPR) algorithms. The VR images (3D.1 and 3D.2) allow you to appreciate the jaw with the double bar split and the osteosynthesis performed in a "panoramic" way. The native axial images (stone1) and the coronal reformats (stone2 and stone3) show the fracture lines and the relationships between the stumps in greater detail, as well as the positioning of the osteosynthetic means and the results of the treatment. Furthermore, the bone density in UH was calculated on the native images and on the selected multiplanar reformats by positioning circular ROIs (region of interest) of approximately 1-3.5 mm². These ROIs were positioned inside the spongy bone close to the fracture lines, taking care not to include the cortex in the measurement. The average UH values obtained

from these measurements showed an extreme compactness of the mandibular spongy bone, with a range between 1078 and 1269 UH, which, according to the Misch classification, falls into the D1-D2 type [20] (Figures 7-9).

In our opinion, another relevant fact is the patient's age, 53 years, which is well above the average of 25-27 years of orthognathic patients, as shown by large case series reported [6,8]. Patients of advanced age, in the absence of significant loss of dental elements, compared to young people, have greater bone mineralization and hardness with a less developed medulla [3,8,9,25].



Figure 7: Axial CT image showing ROI placement for bone density measurement.



Figure 8: Coronal CT section demonstrating fracture relationships and fixation plates.



Figure 9: Volume rendering illustrating double bad split and osteosynthetic material *in situ*.

Conclusion

The cause of the bad split is not known. Among the various hypotheses advanced, there is no reference to the quality of the bone to be osteotomized. This element is highlighted above all in the field of osseointegrated dental implantology [33,34]. Those who perform orthognathic surgery know well that a hard bone is more likely to suffer from unwanted fractures. The SSO can be done by virtue of the fact that the osteotome is placed between the hard cortex and the softer spongiosa. When the osteotome is placed between two rigid bodies, uncontrollable forces are generated.

Proffit, regarding the bad split of the mandibular rami, reports that “the variability of bone density and architecture can cause unexpected fractures that make fixation and stabilization difficult” [35].

Based on this clinical case, we hypothesize that the hardness of the bone is a factor not to be overlooked in the pathogenesis of the bad split, so much so that this observation has pushed us to routinely perform it on all patients who are candidates for SSO, especially if they are older advanced, beyond the usual exams, is CT which allows you to evaluate not only the position of the alveolar canal and the anatomy of the jaw, but also the measurement of bone density.

References

- Guernsey LH, DeChamplain RW. Sequelae and complications of the intraoral sagittal osteotomy in the mandibular rami. *Oral Surg Oral Med Oral Pathol.* 1971;32(2):176–92. Available from: [https://doi.org/10.1016/0030-4220\(71\)90221-0](https://doi.org/10.1016/0030-4220(71)90221-0)
- Van Merkesteyn JP, Groot RH, van Leeuwen R, Kroon FH. Intraoperative complications in sagittal and vertical ramus osteotomies. *Int J Oral Maxillofac Surg.* 1987;16(6):665–70. Available from: [https://doi.org/10.1016/s0901-5027\(87\)80050-4](https://doi.org/10.1016/s0901-5027(87)80050-4)
- Kriwalsky MS, Maurer P, Veras RB, Eckert AW, Schubert J. Risk factors for a bad split during sagittal split osteotomy. *Br J Oral Maxillofac Surg.* 2008;46(3):177–9. Available from: <https://doi.org/10.1016/j.bjoms.2007.09.011>
- MacIntosh RB. Experience with the sagittal osteotomy of the mandibular ramus a 13-year review. *J Maxillofac Surg.* 1981;9(3):151–65. Available from: [https://doi.org/10.1016/s0301-0503\(81\)80036-7](https://doi.org/10.1016/s0301-0503(81)80036-7)
- Van Merkesteyn JP, Groot RH, van Leeuwen R, Kroon FH. Intraoperative complications in sagittal and vertical ramus osteotomies. *Int J Oral Maxillofac Surg.* 1987;16(6):665–70. Available from: [https://doi.org/10.1016/s0901-5027\(87\)80050-4](https://doi.org/10.1016/s0901-5027(87)80050-4)
- Mensink G, Verweij JP, Frank MD, Bergsma JE, van Merkesteyn JP. Bad split during bilateral sagittal split osteotomy of the mandible with separators: a retrospective study of 427 patients. *Br J Oral Maxillofac Surg.* 2013;51(6):525–9. Available from: <https://doi.org/10.1016/j.bjoms.2012.10.009>
- Acebal-Bianco F, Vuylsteke PL, Mommaerts MY, De Clercq CA. Perioperative complications in corrective facial orthopedic surgery: a 5-year retrospective study. *J Oral Maxillofac Surg.* 2000;58(7):775–80. Available from: <https://doi.org/10.1053/joms.2000.7874>
- Chrcanovic BR, Freire-Maia B. Risk factors and prevention of bad splits during sagittal split osteotomy. *Oral Maxillofac Surg.* 2012;16(2):119–27. Available from: <https://doi.org/10.1007/s10006-011-0287-4>
- Mehra P, Castro V, Freitas RZ, Wolford LM. Complications of the mandibular sagittal split ramus osteotomy associated with the presence or absence of third molars. *J Oral Maxillofac Surg.* 2001;59(8):885–8. Available from: <https://doi.org/10.1053/joms.2001.25013>
- Salman S, Young M, Van Sickels JE. Osteomyelitis after bilateral sagittal split osteotomy: case report and a review of the management. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2011;111(4):442–8. Available from: <https://doi.org/10.1016/j.tripleo.2010.06.003>
- Teltzrow T, Kramer FJ, Schulze A, Baethge C, Brachvogel P. Perioperative complications following sagittal split osteotomy of the mandible. *J Craniomaxillofac Surg.* 2005;33(5):307–13. Available from: <https://doi.org/10.1016/j.jcms.2005.04.005>
- Guernsey LH, DeChamplain RW. Sequelae and complications of the intraoral sagittal osteotomy in the mandibular rami. *Oral Surg Oral Med Oral Pathol.* 1971;32(2):176–92. Available from: [https://doi.org/10.1016/0030-4220\(71\)90221-0](https://doi.org/10.1016/0030-4220(71)90221-0)
- O’Ryan F. Complications of orthognathic surgery. *Oral Maxillofac Surg Clin North Am.* 1990;2(1):93–601.
- Turvey TA. Intraoperative complications of sagittal osteotomy of the mandibular ramus: incidence and management. *J Oral Maxillofac Surg.* 1985;43(7):750–4. Available from: [https://doi.org/10.1016/s0278-2391\(85\)80028-8](https://doi.org/10.1016/s0278-2391(85)80028-8)
- Veras RB, Kriwalsky MS, Hoffmann S, Maurer P, Schubert J. Functional and radiographic long-term results after bad split in orthognathic surgery. *Int J Oral Maxillofac Surg.* 2008;37(7):760–6. Available from: <https://doi.org/10.1016/j.ijom.2008.04.010>
- Lee SY, Yang HJ, Han JJ, Hwang SJ. Effect of perioperative buccal fracture of the proximal segment on postoperative stability after sagittal split ramus osteotomy. *J Korean Assoc Oral Maxillofac Surg.* 2013;39(5):217–23. Available from: <https://doi.org/10.5125/jkaoms.2013.39.5.217>
- Epker BN, Fish LC. Dentofacial deformities. St. Louis: Mosby; 1986;1:232–4. Available from: https://search.library.ucdavis.edu/discovery/fulldisplay?vid=01UCD_INST:UCD&tab=Everything&docid=alma990006424270403126
- Gilles R, Couvreur T, Dammous S. Ultrasonic orthognathic surgery enhancements to established osteotomies. *Int J Oral Maxillofac Surg.* 2013;42(8):981–7. Available from: <https://doi.org/10.1016/j.ijom.2012.12.004>
- Akhtar S, Tuinzing DB. Unfavorable splits in sagittal split osteotomy. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 1999;87(3):326–7. Available from: [https://doi.org/10.1016/s1079-2104\(99\)70230-1](https://doi.org/10.1016/s1079-2104(99)70230-1)
- Hounsfield GN. Computerized transverse axial scanning tomography. 1. Description of system. *Br J Radiol.* 1973;46(552):1016–22. Available from: <https://doi.org/10.1259/0007-1285-46-552-1016>
- Misch CE. Second vital implant criterion. *Dental Today.* 1988 :39–40.
- Trauner R, Obwegeser H. Zur Operationstechnik bei der Progenie und anderen Unterkieferanomalien. *Dtsch Zahn Mund Kieferheilkd.* 1955;23:11–26. Available from: <https://www.scirp.org/reference/referenc espapers?referenceid=1257402>
- Dal Pont G. Retromolar osteotomy for the correction of prognathism. *J Oral Surg Anesth Hosp Dent Serv.* 1961;19:42–7. Available from: <https://pubmed.ncbi.nlm.nih.gov/13719390/>
- Shapurian T, Damoulis PD, Reiser GM, Griffin TJ, Rand WM. Quantitative evaluation of bone density using the Hounsfield index. *Int J Oral Maxillofac Implants.* 2006;21 <https://pubmed.ncbi.nlm.nih.gov/16634501/>
- Kingsmill VJ, Boyde A. Mineralisation density of human mandibular bone: quantitative backscattered electron image analysis. *J Anat.* 1998;192(Pt 2):245–56. Available from: <https://doi.org/10.1046/j.1469-7580.1992.0245.x>
- Simpson W. Problems encountered in the sagittal split operation. *Int J Oral Surg.* 1981;10:81–6. Available from: [https://doi.org/10.1016/s0300-9785\(81\)80016-6](https://doi.org/10.1016/s0300-9785(81)80016-6)



27. Muto T, Akizuki K, Tsuchida N, Sato Y. Modified intraoral inverted L osteotomy: a technique for good visibility, greater bony overlap, and rigid fixation. *J Oral Maxillofac Surg.* 2008;66(8):1309. Available from: <https://doi.org/10.1016/j.joms.2007.03.034>
28. Landes CA, Stübinger S, Ballon A, Sader R. Piezoosteotomy in orthognathic surgery versus conventional saw and chisel osteotomy. *Oral Maxillofac Surg.* 2008;12(3):139-47. Available from: <https://doi.org/10.1007/s10006-008-0123-7>
29. Nagadia R, Tay AB, Chan LL, Chan ES. The spatial location of the mandibular canal in Chinese: a CT study. *Int J Oral Maxillofac Surg.* 2011;40(12):1401-5. Available from: <https://doi.org/10.1016/j.ijom.2011.07.904>
30. Agbaje JO, Sun Y, De Munter S, Schepers S, Vrielinck L, Lambrichts I, Politis C. CBCT-based predictability of attachment of the neurovascular bundle to the proximal segment of the mandible during sagittal split osteotomy. *Int J Oral Maxillofac Surg.* 2013;42(3):308-15. Available from: <https://doi.org/10.1016/j.ijom.2012.07.012>
31. Plooi JM, Naphausen MT, Maal TJ, Xi T, Rangel FA, Swennen G, de Koning M, Borstlap WA, Berg SJ. 3D evaluation of the lingual fracture line after a bilateral sagittal split osteotomy of the mandible. *Int J Oral Maxillofac Surg.* 2009;38(12):1244-9. Available from: <https://doi.org/10.1016/j.ijom.2009.07.013>
32. Song JM, Kim YD. Three-dimensional evaluation of lingual split line after bilateral sagittal split osteotomy in asymmetric prognathism. *J Korean Assoc Oral Maxillofac Surg.* 2014;40(1):11-6. Available from: <https://doi.org/10.5125/jkaoms.2014.40.11>
33. De Oliveira RC, Leles CR, Normanha LM, Lindh C, Ribeiro-Rotta RF. Assessments of trabecular bone density at implant sites on CT images. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2008;105(2):231-8. Available from: <https://doi.org/10.1016/j.tripleo.2007.08.007>
34. Song YD, Jun SH, Kwon JJ. Correlation between bone quality evaluated by cone-beam computerized tomography and implant primary stability. *Int J Oral Maxillofac Implants.* 2009 ;24(1):59-64. Available from: <https://pubmed.ncbi.nlm.nih.gov/19344026/>
35. Proffit WR, White RP, Sarver DM. Contemporary Treatment of Dentofacial Deformity. St. Louis: Mosby; 2003. Available from: https://books.google.co.in/books/about/Contemporary_Treatment_of_Dentofacial_De.html?id=fyNqAAAAMAAJ&redir_esc=y