applied sciences

MDPI

Review

Submental Abscess Following Peri-Implantitis: Case Report and Comprehensive Literature Review

Giacomo D'Angeli [1], Lorenzo Arcuri [2,*], Paolo Carosi [3], Marco De Vincentiis [4], Luca Testarelli [1] and Massimo Galli [1]

[1] Department of Oral and Maxillofacial Sciences, Sapienza University of Rome, 00185 Rome, Italy; giacomo.dangeli@uniroma1.it (G.D.)
[2] Department of Life Science, Health and Health Professions, Link Campus University, 00165 Rome, Italy
[3] Department of Chemical Science and Technologies, University of Rome Tor Vergata, 00133 Rome, Italy
[4] Department of Sense Organs, Sapienza University of Rome, 00185 Rome, Italy
* Correspondence: l.arcuri@unilink.it

Abstract: Background: Dental implantology is the greatest popular choice for the treatment of partial or total edentulism. However, despite its apparent simplicity, it represents a technique that necessitates adequate surgical knowledge and significant technical skills. There are several potential complications related to dental implant surgery and some of these can be particularly dangerous. The aim of the present study is to make a comprehensive review of head and neck abscess as a complication of dental implant infections and the consequent medical and therapeutic approach. **Case report**: A case of submental abscess related to peri-implantitis is presented from the hospital access to the emergence surgical treatment and medical therapy. The patient presented with painful swelling in the right submental and submandibular region. The surgical procedure included both an extraoral and intraoral approach. Extraorally, a right paramedian submental incision was performed. Intraorally, after removal of the fixed prosthesis screwed to a single implant, a muco-periosteal flap was elevated in correspondence of the third and fourth quadrants to allow implant exposure. All implant sites of infection and possible complications were removed. Then, Penrose-type drains were positioned intraorally and extraorally. **Results**: The patient remained hospitalized for ten days for clinical conditions assessment, the wounds were treated, and the drains replaced. Laboratory tests showed that neutrophils and PCR returned to normal values, indicating an interruption of the inflammatory process. The patient was discharged in good general and local clinical conditions with dedicated therapy. **Conclusions**: At 5-month follow-up the swelling had vanished and tissues appeared normotrophic and healthy. However, a computed tomography (CT) scan of the lower arch showed significant generalized bone loss at the mandibular level compatible with a state of advanced bone atrophy. The early diagnosis and treatment of these complications is fundamental for the patient prognosis.

Keywords: dental implant; submental abscess; peri-implantitis; infection; malpractice

Academic Editor: Tommaso Lombardi

Received: 20 January 2025
Revised: 20 February 2025
Accepted: 21 February 2025
Published: 24 February 2025

Citation: D'Angeli, G.; Arcuri, L.; Carosi, P.; De Vincentiis, M.; Testarelli, L.; Galli, M. Submental Abscess Following Peri-Implantitis: Case Report and Comprehensive Literature Review. *Appl. Sci.* **2025**, *15*, 2398. https://doi.org/10.3390/app15052398

1. Introduction

Implant therapy is currently the most widespread method for the treatment of partial or total edentulism and, despite its apparent simplicity, it is a procedure that requires considerable technical skills and in-depth surgical knowledge. Even dental implants can in some cases become the source of an infectious process; in these cases, iatrogenic error often assumes a certain relevance, where the general principles of surgery and the adequate

rules of asepsis are not respected [1,2]. In fact, despite the high safety procedures adopted, implant surgery is not free from the possible development of complications [3–5].

Most complications are directly apparent, but some can occur much later. Most complications can be anticipated during treatment planning and execution and therefore are preventable. Minor bleeding is inherent during the placement of dental implants, as with any surgical procedure. However, major bleeding is rare and can be life threatening. The causes of major bleeding may be related to systemic issues or regional anatomy characteristics. Failure to recognize variations in the regional anatomy of the maxilla and mandible can be the cause of major bleeding during implant placement.

Some publications have reported bleeding, in some cases life-threatening hemorrhage, after the placement of implants in the anterior mandible [6–9]. The cause of bleeding during implant placement in the anterior mandible is perforation of the lingual cortex, resulting in injury to the terminal branches of the sublingual or submental artery [8,10]. The risk of perforation is high when the lingual fossa is very deep and is even advanced when no flap is elevated during the procedure. Several techniques are available for assessing potential implant sites in both the anterior and posterior regions of the mandible, including both clinical assessment and radiographic evaluation of the proposed site. The results of palpation of the ridge are variable; however, during the procedure, dissection of the lingual aspect of the mandible can determine its curvature and help to prevent perforation. An examination using a facial computed tomography (CT) with attention to the lingual aspect of the mandible also alerts the surgeon to possible risks of perforation in this region.

Management of bleeding once perforation has occurred requires both control of the hemorrhage and security of the airways. In the early stages, when hemorrhage is seen in the floor of the mouth, basic measures should be taken, including direct bimanual compression at the suspected perforation site and control of the patient's blood pressure if elevated. If hemorrhage is severe, it is almost impossible to visualize the anatomy in the affected area. Retraction of the artery after laceration makes ligation difficult or unmanageable. If operative intervention is necessary for controlling the hemorrhage, an extraoral approach for ligation procedures is preferred [7]. Surgical intervention for ligation of vessels is frequently unnecessary, but the patient may need to be intubated for several days for airway protection. Antibiotics should be used to prevent infection when hematomas are extensive, principally in the case of intraoral communication. Steroid therapy should also be considered for reducing swelling [7,11].

A CT should be included in the planning stages for implant placement in the anterior region of the mandible to clearly visualize the mandibular anatomy and evidence eventual anatomical variables [12–15].

Numerous cases of displacement or migration of implants into adjacent spaces have been published, usually as case reports [16–18].

Intraoperative and early displacement of dental implants has been attributed to low bone density, thin cortical bone, anatomic differences, previous infection, osteopenia or osteoporosis, and poor surgical technique. Displacement and migration of dental implants have been reported to occur in the maxillary sinus, sphenoid sinus, and ethmoid sinus [16,17]. They have also been reported to perforate the nasal floor and, in one case, the anterior cranial fossa [19].

Cases of implant migration into maxillary sinus are frequently reported; however, implant displacement into other anatomical spaces like the nasal cavity is uncommon [18].

Generally, these types of complications result from planning errors or surgical inexperience. When implants migrate into the sinus, there may or may not be signs or symptoms of infection, but there will likely be an oral–antral communication. If infection occurs, it may involve the adjacent sinuses. Therefore, the removal of displaced implants is recommended.

Implants that are displaced into the maxillary sinus can be removed with a Caudwell–Luc procedure or by a trans nasal approach with functional endoscopic sinus surgery.

One case report described the displacement of a dental implant into the anterior cranial fossa and its endoscopic removal. A dural repair was necessary for treating a subsequent leak of cerebral spinal fluid. The authors did not describe the placement of this implant [19]. A retrospective analysis of 244 cases of complications after the placement of zygomatic implants found 2 cases of subcutaneous malar emphysema caused by dislocation of the tip of the implant burs in the zygomatic–facial region. The subcutaneous emphysema resolved naturally by resorption of the air [20].

The sublingual salivary gland can be injured when an implant is placed in the posterior mandible [21]. The contiguity of the sublingual gland to the lingual cortex of the mandible, which lies directly below the mylohyoid muscle, makes it susceptible to injury if penetration occurs in this area.

Cases of development of neck and mediastinal abscesses with serious compromise of the patient's health conditions have been found in the literature [22–33]. Some cases described severe complications like descending necrotizing mediastinitis following osseointegrated dental implant placement [22–24]. Chest and neck CT images can reveal detailed information regarding the extent of the necrotizing process, and suggest, within the surgical treatment, the best approach for an effective drainage. The most common CT findings included increased attenuation of mediastinal fat, localized mediastinal fluid collections, free gas bubbles in the mediastinum, pleural effusions and sternal dehiscence [34].

Submandibular space infections are potentially lethal infections. Airway obstruction and spread of infection to the mediastinum are the most troublesome complications. Therefore, the maintenance of a secure airway is paramount and aggressive treatment is justified. Patients with cellulitis and small abscesses can respond to antibiotics alone. A surgical drainage should be performed in patients with larger abscesses, Ludwig's angina, anterior visceral space involvement, and in those who do not respond to antibiotic treatment [25]. The literature reports some cases of Ludwig's angina as a complication of odontogenic infections. Ludwig's angina is a condition that could be fatal, causing severe diffuse cellulitis bilaterally that affects the submandibular, sublingual, and submental areas. It has an acute onset and progresses rapidly. A common and potentially deadly complication is airway impairment. Most cases of Ludwig's angina are odontogenic in etiology, primarily resulting from infections of the lower second and third molars. These cases demonstrate the lethal effects of odontogenic infections [26–29,33].

Recently, peri-implantitis has become one of the most frequent late complications of dental implants with the risk of developing serious inflammatory processes.

Peri-implantitis is defined as "a pathological condition affecting the tissues around implants, characterized by inflammation of the peri-implant connective tissue and progressive loss of supporting bone"; it has an incidence ranging from less than 7% to 37% of implants and can be perpetuated by a bacterial infection that has contaminated the implant surface and by excessive biomechanical forces [3–5,35]. Peri-implantitis today, if not intercepted in the early stages, is considered an irreversible process, which presents as the main therapy the surgical removal of the implant [36–40].

Clinical signs such as fever, dysphagia, pain, swelling and trismus should be considered alarm bells of possible surgical infection; finally, a head and neck CT remains the most important diagnostic tool [6,41–44].

The aim of this work is to describe a case of submental abscess caused by peri-implantitis. The following clinical case represents an example of a diagnostic and surgical procedure of a neck abscess, involving the submandibular and submental region, starting from an infection involving dental implants.

2. Case Description

A 77-year-old man (Caucasian) went to the emergency room of the Policlinico Umberto I with an evident swelling of the neck, which involved the right submental and submandibular region (Figure 1).

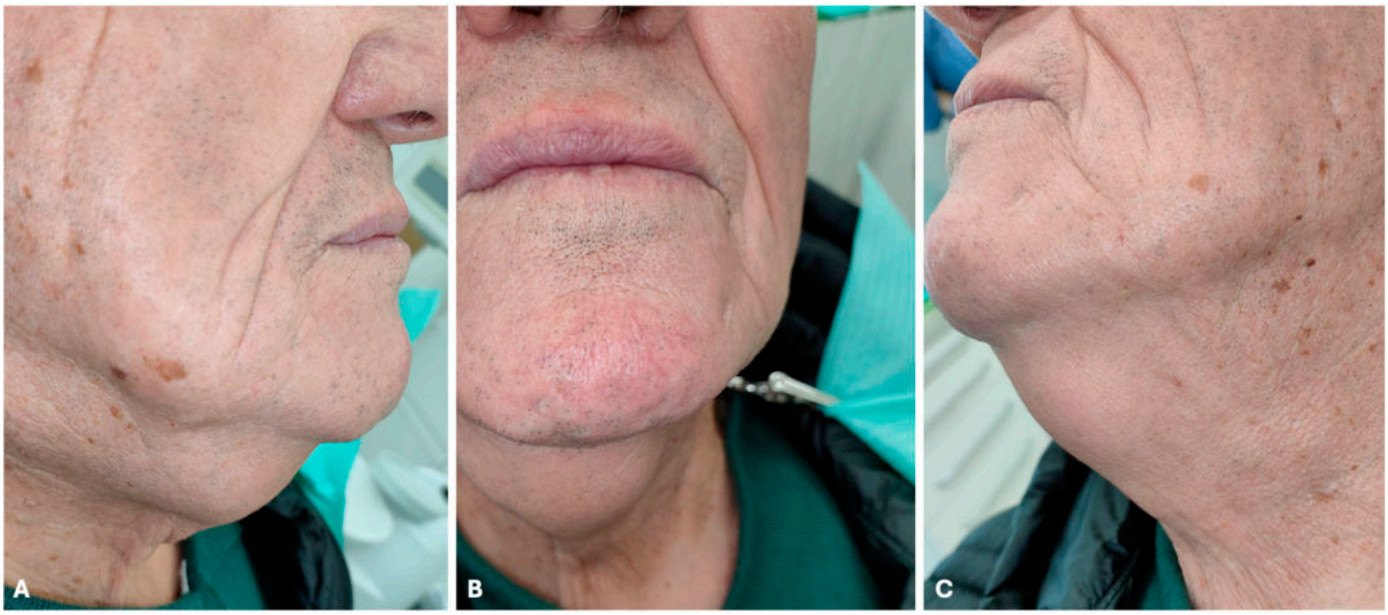

Figure 1. Extra-oral view of swelling of the neck (**A**) right view. (**B**) frontal view. (**C**) left view.

The following day, he was admitted to the Otorhinolaryngology (ENT) Ordinary Hospitalization Department with an admission diagnosis, later confirmed, of a right submental and submandibular abscess of possible dental implant origin. In the immediate pathological anamnesis, the patient reported that approximately 15 days before he had undergone surgery for the insertion of four dental implants (bone level) in the mandibular area, which was followed by the appearance of a painful swelling in the right submental and submandibular region. Following this, the patient took a pharmacological therapy with amoxicillin and acid clavulanic 1 g (Augmentin®, GlaxoSmithKline, Brentford, UK) and Betametasone 1 mg (Bentelan®, Alfasigma S.p.A, Bologna, Italy) for 6 days, but without having any benefits, and instead reported a worsening of the symptoms and difficulty in swallowing. From the remote pathological anamnesis, arterial hypertension, hyperuricemia and hypercholesterolemia are highlighted and pharmacologically managed with Allopurinolo 300 mg (Zyloric®, Teofarma S.r.l., Pavia, Italy), Telmisartan 80 mg (Micardis®, Boehringer Ingelheim Italia S.p.A., Milan, Italy), Atorvastatina 10 mg (Totalip®, A. Menarini Manufacturing Logistics and Services S.r.l., l'Aquila, Italy). On extraoral objective examination, the swelling appeared warm, painful, mobile, of a tense-elastic consistency and with normotrophic surrounding skin. The intraoral objective examination confirmed the recent introduction of dental implants at the mandibular level and the presence of hyperemic surrounding soft tissues. The orthopantomography, performed four days before access to the emergency room, showed clear signs of inflammation and bone resorption in the mandibular arch, evidenced by osteolytic areas of radiolucency both around the recently inserted implants and around the only previously inserted implant that appeared to support alone the lower prosthesis (Figure 2).

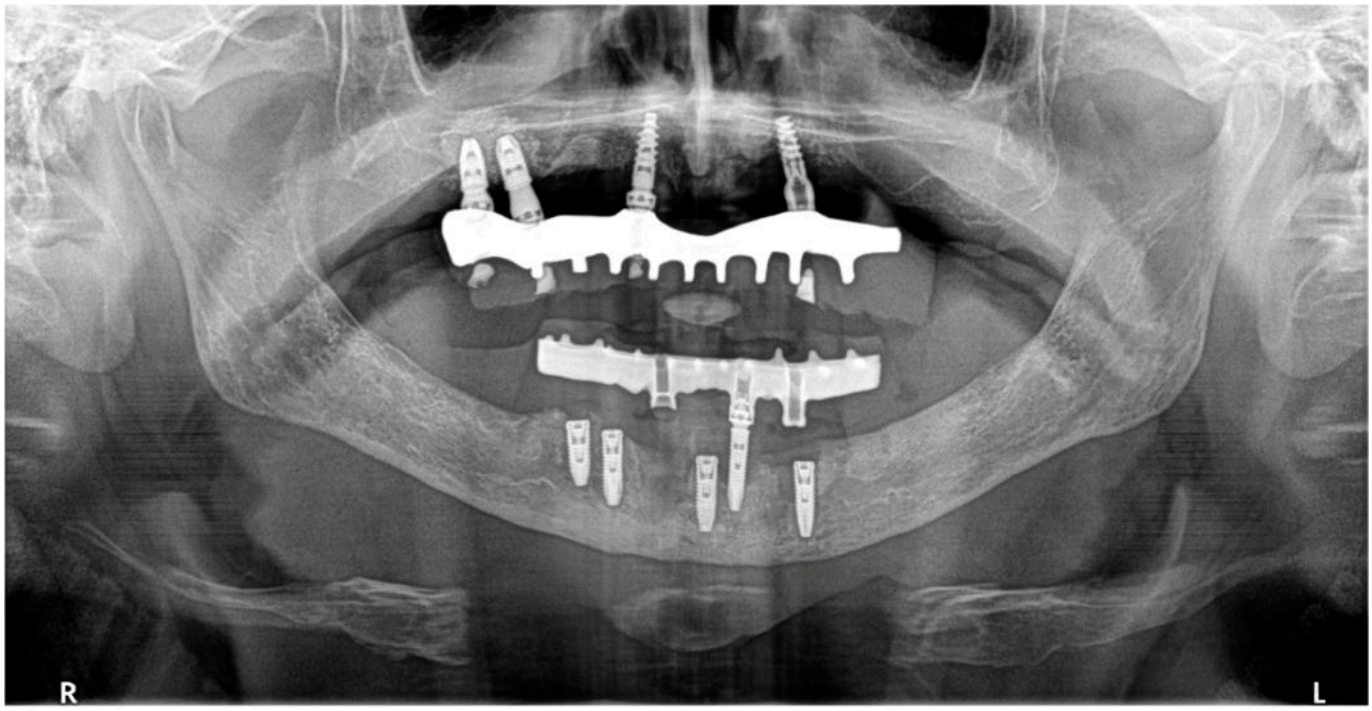

Figure 2. Preoperative panoramic X-ray.

Previous panoramic X-rays showed that the patient had already undergone previous failed attempts of implant rehabilitation. The panoramic X-ray, performed approximately nine months before hospitalization, showed that of the seven implants previously inserted three years earlier in the lower arch, only three remained and had also undergone a significant process of peri-implantitis and bone resorption (Figure 3).

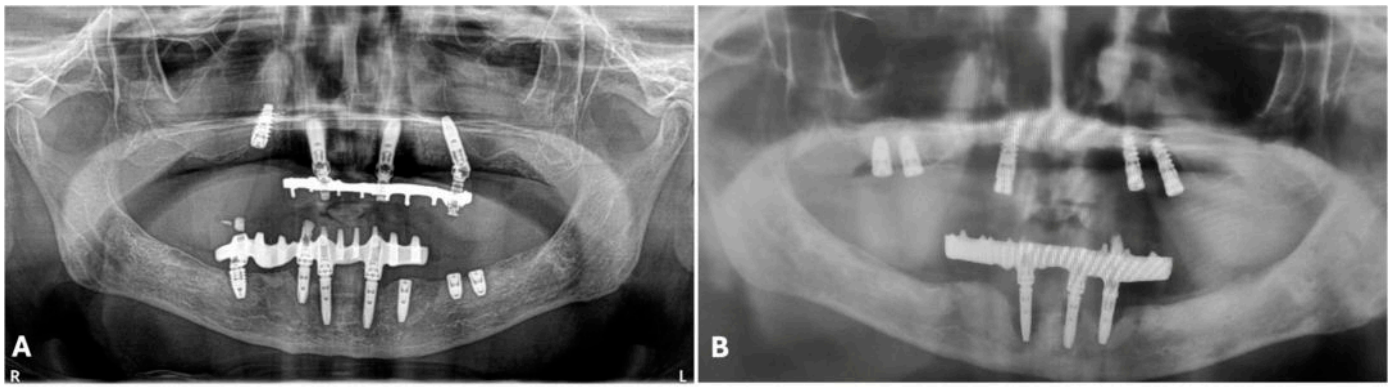

Figure 3. Previous panoramic X-rays (**A**) panoramic X-ray three years earlier. (**B**) panoramic X-ray nine months earlier.

The development of cervical swelling would therefore appear to be related to the formation of a peri-implant infectious process in a region that had already been previously weakened in terms of both soft and hard tissues. In fact, the therapeutic rage would have allowed the infectious process to make its way through anatomical structures that were now compromised and to reach the spaces of the neck by gravity. An urgent CT scan of the head and neck area was requested and performed, before and after the administration of contrast medium. The report confirmed the presence of an abscess in the right submental and submandibular area, with a multi-chambered appearance, which infiltrated the mylohyoid, genioglossus muscles and the submandibular gland. The infectious process slightly compressed but did not exceed the hyoid bone, located at the third and fourth cervical

vertebrae; the lack of involvement of the hyoid bone at the time of admission confirmed that the infection had not yet invaded the airways. In the axial cuts it was possible to observe the infectious process affecting the implants, that caused an interruption of the right lingual cortex, probably representing the infectious path from the oral cavity to the neck region (Figure 4).

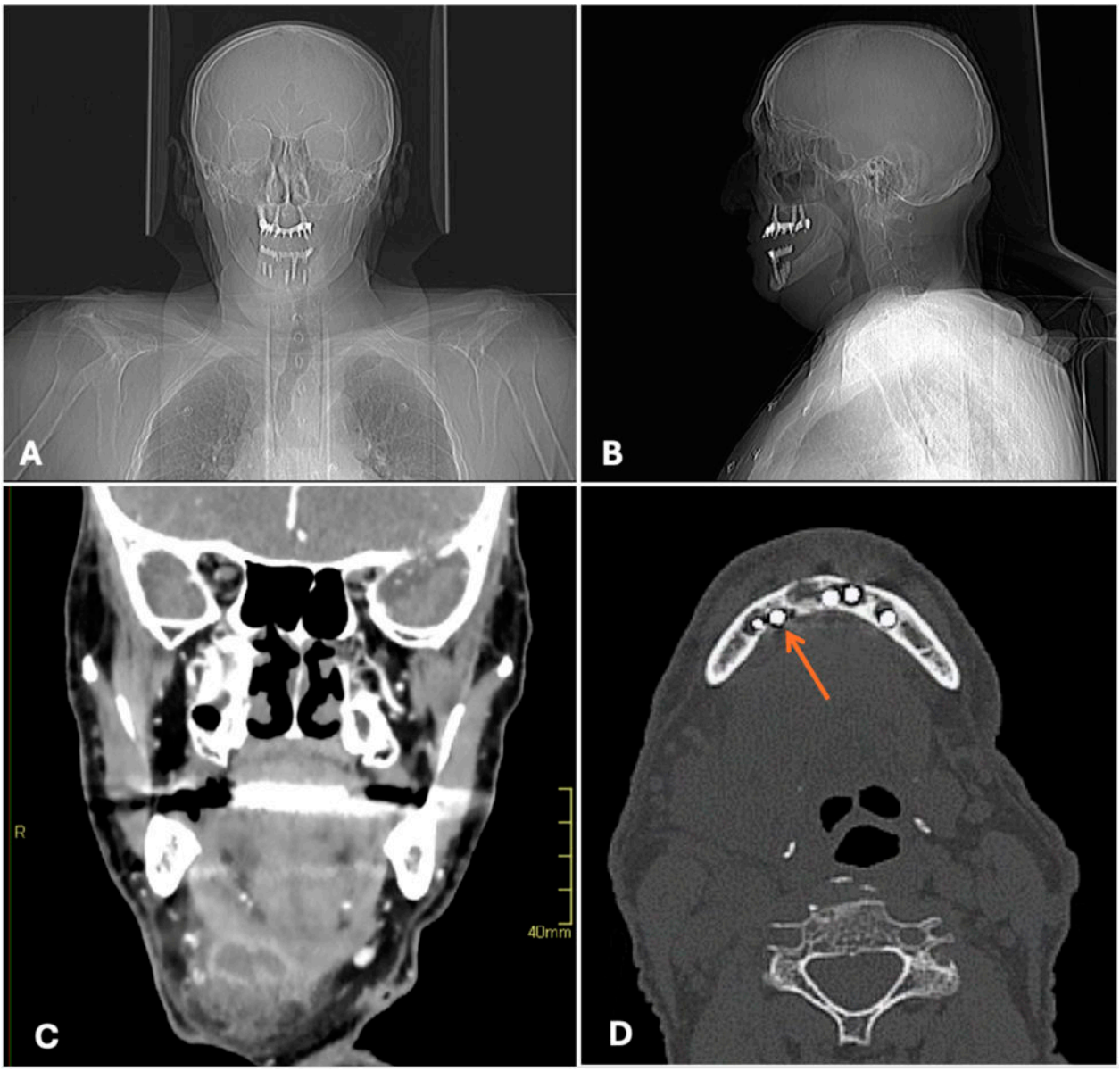

Figure 4. CT scan showing the presence of an abscess in the right submental and submandibular area, with a multi-chambered appearance, which infiltrated the mylohyoid, genioglossus muscles and the submandibular gland. (**A**,**B**) the air column, at the level of the hypopharynx, was slightly displaced to the left, but without compression. (**C**) coronal cut highlights the involvement of the abscess in the right submental and submandibular area. (**D**) we can observe how the infectious process affecting the implants has caused an interruption of the right lingual cortex (red arrow).

Laboratory tests showed an increased number of neutrophils and high values of C-reactive protein (PCR) (1.4 mg/dL compared to the reference values 0–0.5). LDH (lactate dehydrogenase) value was also increased (282 units per liter (U/L) compared to the normal range of 135–225 (U/L), indicating a destructive cellular process of an inflammatory nature. The patient underwent surgical drainage of the abscess collection and removal of the dental implants; the procedure required interdisciplinary collaboration between an anesthetist,

an ENT specialist, and an oral surgeon. Surgery was carried out under general anesthesia (TL1), by nasotracheal intubation, due to the invasiveness of the surgery. Anesthesia was induced by Propofol B. Braun (2 mg per kg), then Fentanyl (3 mcg per kg) and Esmeron (0,6 mg per kg) were administered. The patient was ventilated with 1% Sevorane in 65% Nitrous Oxide (N_2O)/35% Oxygen (O_2). Infiltrative local plexus anesthesia with vasoconstrictors was performed lingually and buccally along the interforaminal area. The surgical procedure included both an extraoral and intraoral approach. Extraorally, a right paramedian submental incision was performed, followed by an incision of the superficial cervical fascia, which immediately allowed the drainage of the purulent material; subsequently, the dissection continued up to the floor of the oral cavity, to complete the cleaning of the abscess cavity and provide for accurate hemostasis. Intraorally, after removal of the fixed prosthesis screwed to a single implant, a muco-periosteal flap was elevated in correspondence of the third and fourth quadrants to allow implant exposure. Once the implants, which already had mobility and poor bone stability, were exposed, they were removed starting from the affected side, and the purulent material was drained (Figure 5).

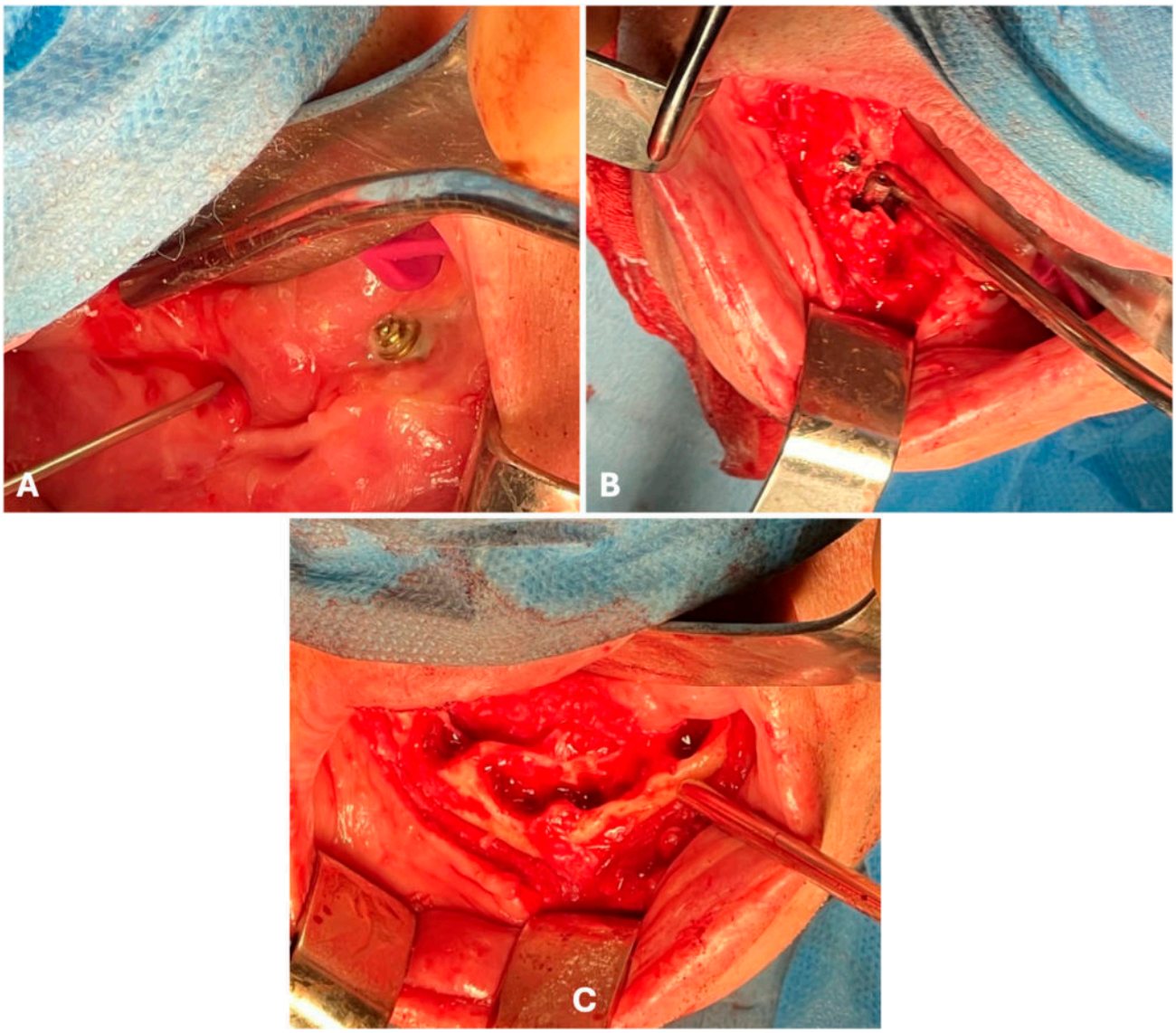

Figure 5. Intra-operative view (**A**) of the only implant that supported the lower prosthesis. (**B**) view of exposed implants affected by peri-implantitis. (**C**) residual bone cavity.

Once the implants were removed at the abscess site, a hemostatic forceps was inserted into the access cavity, first closed and then opened inside in various directions, to obtain a deepening of the underlying planes by blunt means and in complete safety with respect to the surrounding noble anatomical structures (Figure 6).

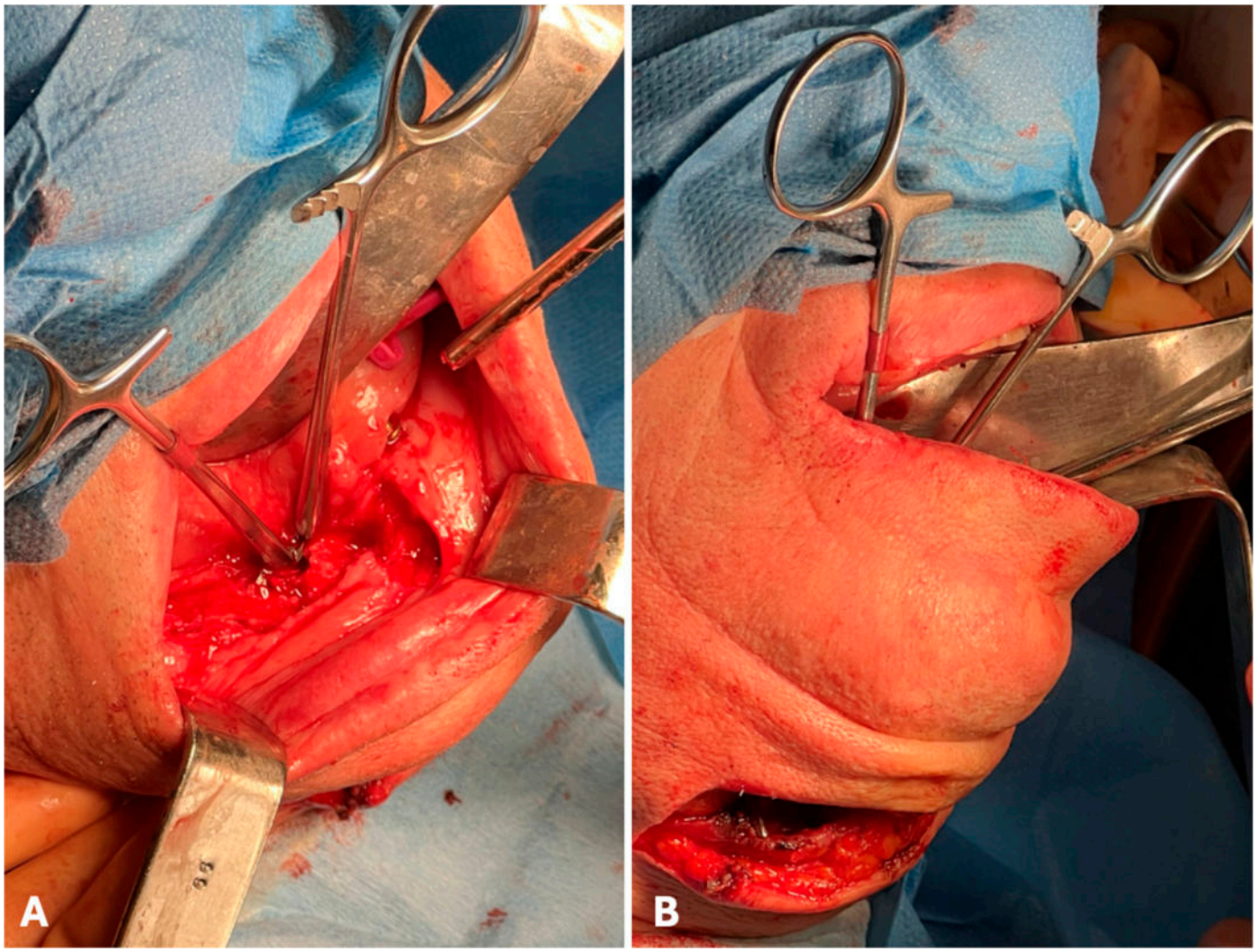

Figure 6. (**A**,**B**) Hemostatic forceps inserted into the access cavity, to obtain a deepening of the underlying planes by blunt means and in complete safety.

Using a sterile gauze inserted from the intraoral side and brought out through the extraoral incision, the cervico-oral communication was regularized, ensuring its patency and complete removal of the infected material. Then the remaining implants, site of infection, and possible complications, were removed (Figure 7).

After regularizing the alveolar cavities, Spongostan (Johnson & Johnson Medical S.p.A., Cologno Monzese, Milan, Italy)) was inserted for hemostatic purposes and Penrose-type drains were positioned intraorally and extraorally, kept in place by a continuous suture of both quadrants in Vicryl 3/0 (Ethicon, Jhonson&Jhonson, New Brunswick, NJ, USA).

The patient remained hospitalized for ten days for clinical condition assessments, the wounds were treated, and the drains replaced. Laboratory tests showed that neutrophils and PCR returned to normal values, indicating an interruption of the inflammatory process. The patient was discharged in good general and local clinical condition with the following home therapy: Augmentin® 1 gr, 1 tablet every 8 h for 7 days, Paracetamolo 1 g Tachipirina® (Angelini Pharma S.p.a., Rome, Italy) as needed, Deltacortene® 25 mg, (Prednisone, Bruno

Farmaceutici S.p.A., Rome, Italy) 1 tablet after breakfast for 3 days, then ½ tablet after breakfast for another 3 days and Chlorhexidine 0.2% mouthwash, oral rinses 3 times a day. Check-ups were performed at 1 and 2 weeks and 1 month, showing a good state of healing of the tissues. After 5 months the complete disappearance of the swelling and general appearance of the tissues was confirmed. Even at the intraoral level, the soft tissues appeared totally healthy and perfectly healed; however, a significant atrophic state of the arch is evident following the infectious process (Figure 8).

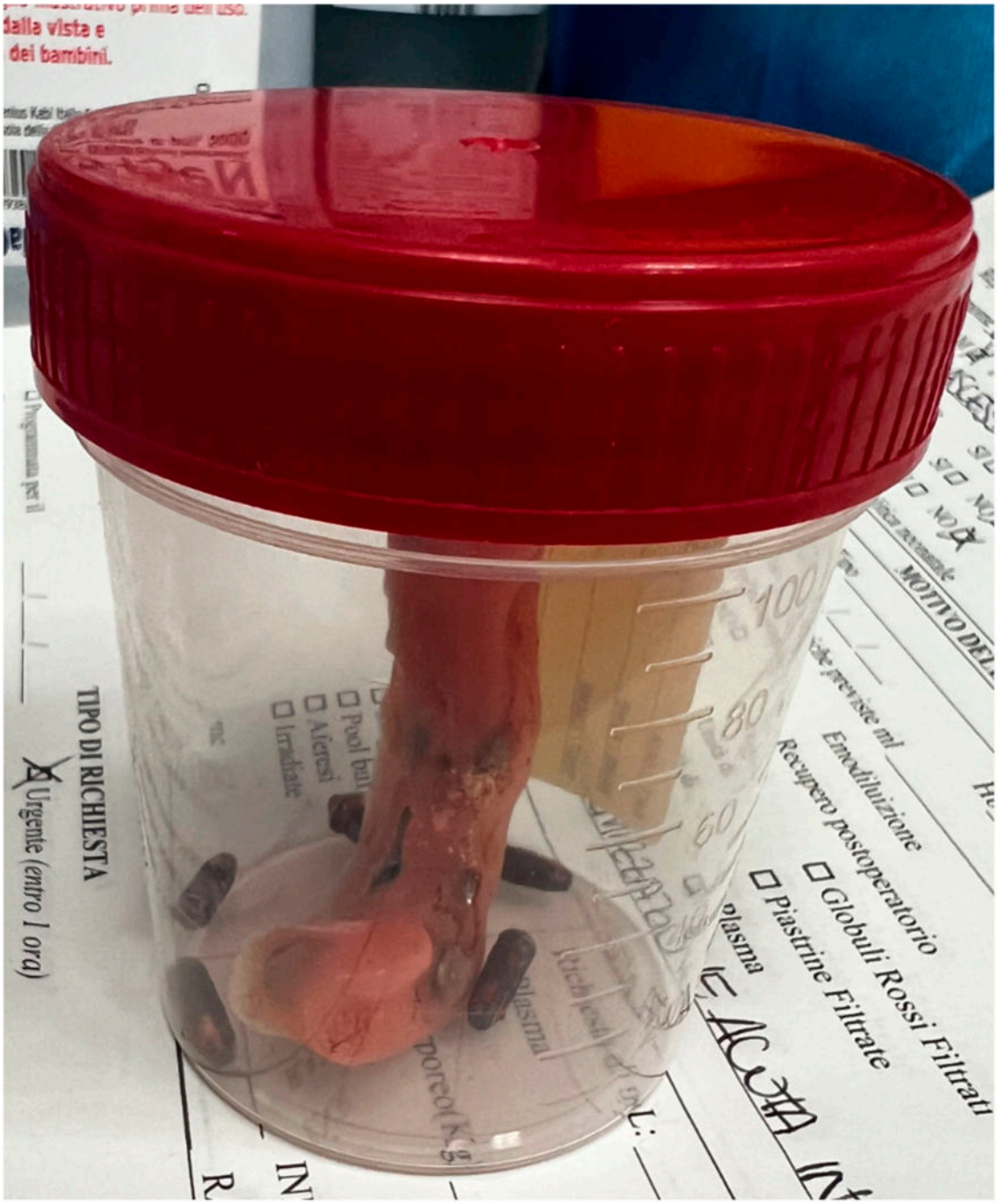

Figure 7. Implants removed.

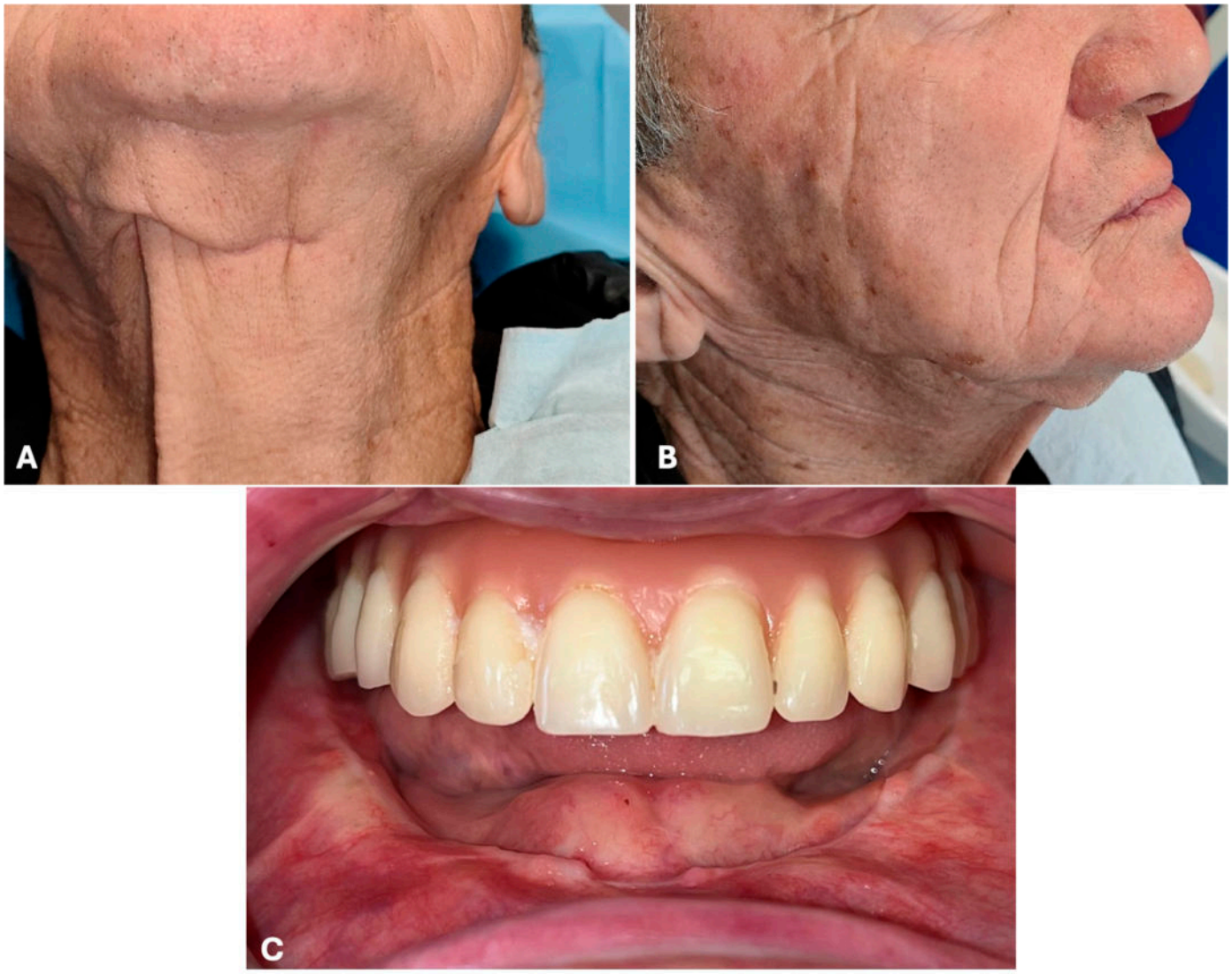

Figure 8. Extraoral and intraoral view post-surgery. (**A**) frontal view; (**B**) right view. Disappearance of the swelling with normotrophic and healthy tissues. (**C**) Intraoral view, healthy soft tissues and evident bone atrophy.

At 5-month follow-up, a CT scan was performed showing generalized bone loss at the mandibular level, with involvement of the right lingual cortex, and a state of bone atrophy at the level of the entire mandibular arch with superficialization of the inferior alveolar nerve (Figure 9).

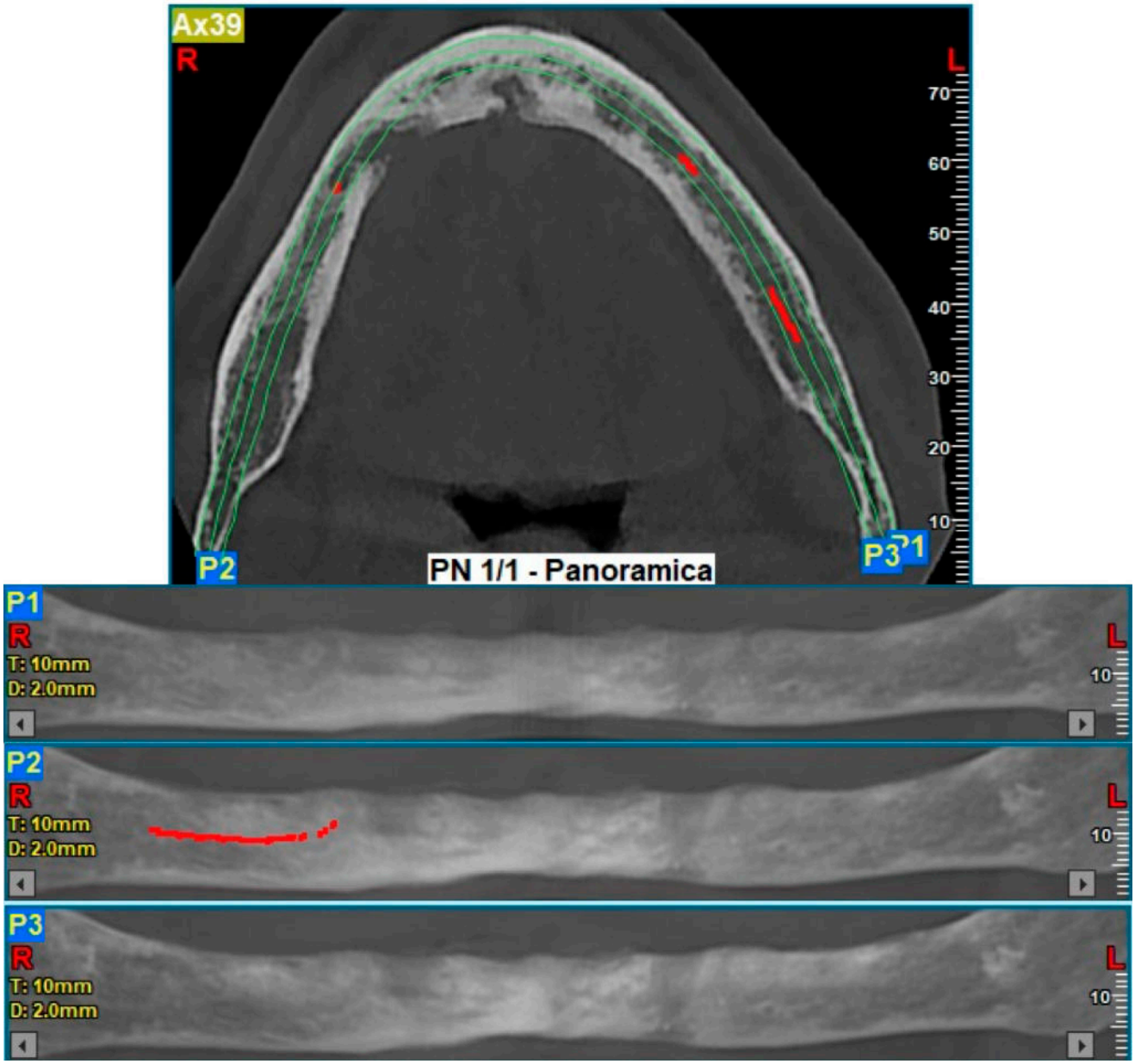

Figure 9. 5-month follow-up CT scan. Red line = inferior alveolar nerve.

3. Discussion

Dental implant surgery is a clinically well documented and validated treatment procedure in dentistry and is a safe surgical procedure with overall high success rates. However, surgical inexperience, insufficient planning, changes in intranasal sinus pressure, autoimmune reaction, peri-implantitis or bone resorption, improper occlusal forces, and bone deficiencies could be responsible for implant displacement complications. The literature reports that late hemorrhages, bone dehiscences, infections, and implant failures are among the most frequent post-operative complications [45–48]. Only a few cases have been described in the scientific literature as experiencing such severe complications after dental implant surgery [1,22–24,45,49].

Of these few works, three described the displacement of implants in the submandibular region as the trigger for the inflammatory process; one described a potentially lethal hemorrhage after implant surgery with perforation of the lingual cortex, and two described necrotizing mediastinitis following the insertion of implants in the mandible. All clinical

cases share potentially lethal complications and emergency surgical management supported by medical therapy.

Early stages of peri-implantitis can be treated with Low-Level Laser and Antimicrobial Photodynamic Therapy protocols used to reduce periodontal biofilm cultures, with the superiority of antimicrobial photodynamic therapy [50].

Laser treatment can result in a short-term reduction in periodontal pocket depth, while air powder abrasive is efficient in cleaning a previously contaminated implant surface. Surgical elimination of a pocket, bone recontouring and plaque control are also applicable for treating peri-implantitis [51].

However, in this case none of these treatments would have been effective given the severity of the disease.

Complications can be avoided or reduced by proper patient selection and evaluation. A careful evaluation and understanding of the bone anatomy and architecture, including the quantity and quality of available bone, are mandatory before implant placement. In addition to the physical examination and CT scan with the patient wearing a radiopaque lined stent yields valuable information and aids in the planning process. A thorough clinical and radiographic examination can be helpful in determining morphologic abnormalities and reducing the incidence of operative complications, such as perforation of the lingual cortex, associated bleeding, and damage to contiguous structures [49–51]. An important difference in the time of onset of peri-implantitis between patients with systemic disease and healthy patients has been confirmed. Hypertension, diabetes mellitus and osteoporosis have an important influence on the early onset of peri-implantitis [52].

The possibility that a peri-implant infectious process can contaminate spaces or organs in continuity with the oral cavity, although rare, appears to be associated with a series of pre-operative, intra-operative and post-operative factors, in which iatrogenic error often assumes a predominant position [53–60]. It is known that white blood cells and PCR can be considered as effective indicators to signal the presence of an infectious process, evaluating its severity and monitoring the effectiveness of the treatment regimen in patients affected by infections of the head and neck area [61–63]. From the radiographic investigations and the reconstruction of the patient's dental clinical history it appears evident that the origin of the complication is clear medical responsibility on the part of the previous dental operator. Among the intraoperative factors, the literature reports that one of the most common causes that can lead to the opening of an infection route between the oral cavity and the underlying areas is the perforation of the lingual cortex during the positioning of an implant [64–67]. As in our case, the preoperative CT shows the evident interruption of the lingual cortex in correspondence with the implants positioned in the right hemiarch; this interruption would seem to be also due, in addition to a positioning of the implant very close to the lingual cortex itself, to a series of wrong choices made over the years by the operator.

The patient, as evidenced by the panoramic X-ray dating back to three years earlier, had already undergone at least two subsequent interventions for the positioning of implants in the lower arch, some of which presented characteristics of suffering and then failed. From the panoramic X-ray performed nine months before hospitalization, it is evident that of the seven previously inserted implants, only three affected by peri-implantitis remained with a consequent severe bone loss. From the most recent panoramic X-ray, it is clear that only one of the three previous implants was left in situ, in order to fully support the lower prosthesis; the latter represents another factor that probably played an important role in determining an imbalance of forces on the bone and further resorption; it can be noted that, compared to the previous panoramic X-ray, four more implants were inserted, one of which (the first on the left) was in the same location (already evidently weakened)

of a previously removed implant. At the time of the surgical drainage of the abscess, none of these implants presented characteristics of primary stability within the bone. The result was the therapeutic obstinacy considered one of the main factors that led to the dissemination of the infectious process from the mandibular region to the cervical region with the fortune of having intercepted the pathology before it involved the respiratory tract and the mediastinum; the abscesses that involve the submandibular region, due to the anatomical position of this space, can easily degenerate into even fatal complications such as Ludwig's Angina or necrotizing descending mediastinitis [10–14,17].

Recently featuring among the innovative procedures to combat peri-implantitis, we include the use of platelet factors and chitosan clotting, which help decrease the risk of implant loss by ensuring better implant stability. Ample data indicate that usage of Platelet-rich plasma (PRP) and platelet-rich fibrin (PRF) in oral surgery shows promising results, as well as the chitosan coating thanks to its potential to increase healing and antiseptic activity [68,69].

4. Conclusions

The possibility that an infection involving an implant may degenerate into the involvement of other spaces or organs in direct communication with the oral cavity is an eventuality that should not be underestimated. Although the incidence is relatively low, all precautions should be taken in terms of prevention, evaluation of risk factors, planning of surgical treatment and intra-operative management to avoid this type of problem. This case demonstrates the importance of an early diagnosis, which involves rapid recognition of the clinical symptoms, and of a multidisciplinary surgical approach in the treatment of this type of situation and in the prevention of worse complications. Trismus, diffuse swelling of the floor of the mouth, dysphonia, dysphagia, and dyspnea are all alarming symptoms. All patients presenting these symptoms and a history of oral surgery should be referred to an emergency room as soon as possible.

Author Contributions: Conceptualization, G.D., L.A. and M.G.; methodology, G.D., L.A. and P.C.; validation, M.D.V., L.T. and M.G.; formal analysis, G.D., L.A. and P.C.; investigation, G.D., L.A., P.C. and M.G.; resources, M.D.V., L.T. and M.G.; writing—original draft preparation, G.D., L.A. and P.C.; writing—review and editing, M.D.V., L.T. and M.G.; visualization, G.D., L.A. and M.G.; supervision, M.D.V., L.T. and M.G.; project administration, M.D.V., L.T. and M.G. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Informed Consent Statement: Informed consent was obtained from the subject involved in the study.

Data Availability Statement: Data are available from the corresponding author upon reasonable request.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Cariati, P.; Perez de Perceval Tara, M.; Fernandez Solis, J.; Martinez Lara, I. Massive Bilateral Neck Abscess and Acute Mediastinitis Following Dental Implant Surgery. *J. Craniofac. Surg.* **2019**, *30*, 1840–1841. [CrossRef]
2. Quirynen, M.; De Soete, M.; van Steenberghe, D. Infectious risks for oral implants: A review of the Literature. *Clin. Oral Implant. Res.* **2002**, *13*, 1–19. [CrossRef] [PubMed]
3. Camargo, I.B.; Van Sickels, J.E. Surgical complications after implant placement. *Dent. Clin. N. Am.* **2015**, *59*, 57–72. [CrossRef]
4. Schwarz, F.; Derks, J.; Monje, A.; Wang, H.L. Peri-implantitis. *J. Clin. Periodontol.* **2018**, *45* (Suppl. S20), S246–S266. [CrossRef] [PubMed]
5. Pye, A.D.; Lockhart, D.E.; Dawson, M.P.; Murray, C.A.; Smith, A.J. A review of dental implants and infection. *J. Hosp. Infect.* **2009**, *72*, 104–110. [CrossRef] [PubMed]

6. Parnia, F.; Fard, E.M.; Mahboub, F.; Hafezeqoran, A.; Gavgani, F.E. Tomographic volume evaluation of submandibular fossa in patients requiring dental implants. *Oral Surg. Oral Med. Oral Pathol. Oral Radiol. Endodontol.* **2010**, *109*, e32–e36. [CrossRef] [PubMed]
7. Niamtu, J., 3rd. Near-fatal airway obstruction after routine implant placement. *Oral Surg. Oral Med. Oral Pathol. Oral Radiol. Endodontol.* **2001**, *92*, 597–600. [CrossRef] [PubMed]
8. Woo, B.M.; Al-Bustani, S.; Ueeck, B.A. Floor of mouth haemorrhage and life-threatening airway obstruction during immediate implant placement in the anterior mandible. *Int. J. Oral Maxillofac. Surg.* **2006**, *35*, 961–964. [CrossRef] [PubMed]
9. Dubois, L.; de Lange, J.; Baas, E.; Van Ingen, J. Excessive bleeding in the floor of the mouth after endosseus implant placement: A report of two cases. *Int. J. Oral Maxillofac. Surg.* **2010**, *39*, 412–415. [CrossRef]
10. Tarakji, B.; Nassani, M.Z. Factors associated with hematoma of the floor of the mouth after placement of dental implants. *Saudi Dent. J.* **2012**, *24*, 11–15. [CrossRef]
11. El-Kholey, K.E. Efficacy of two antibiotic regimens in the reduction of early dental implant failure: A pilot study. *Int. J. Oral Maxillofac. Surg.* **2014**, *43*, 487–490. [CrossRef] [PubMed]
12. Barrientos-Lezcano, F.J.; Corchero-Martín, G.; González-Núñez, A.B.; Soler-Presas, F. Life-Threatening Sublingual Hematoma after Mandibular Implant Placement—A Case Report. *Ann. Maxillofac. Surg.* **2021**, *11*, 169–172. [CrossRef] [PubMed]
13. Law, C.; Alam, P.; Borumandi, F. Floor-of-Mouth Hematoma Following Dental Implant Placement: Literature Review and Case Presentation. *J. Oral Maxillofac. Surg.* **2017**, *75*, 2340–2346. [CrossRef] [PubMed]
14. Schnetler, C.; Todorovic, V.S.; van Zyl, A.W. Anterior Mandibular Lingual Defect As a Possible Cause of Near-Fatal Bleeding During Routine Dental Implant Surgery: A Retrospective Computed Tomography Study. *Implant. Dent.* **2018**, *27*, 254–259. [CrossRef]
15. Vehmeijer, M.J.J.B.; Verstoep, N.; Wolff, J.E.H.; Schulten, E.A.J.M.; van den Berg, B. Airway Management of a Patient with an Acute Floor of the Mouth Hematoma After Dental Implant Surgery in the Lower Jaw. *J. Emerg. Med.* **2016**, *51*, 721–724. [CrossRef]
16. Dimitriou, C.; Karavelis, A.; Triaridis, K.; Antoniadis, C. Foreign body in the sphenoid sinus. *J. Cranio-Maxillofac. Surg.* **1992**, *20*, 228–229. [CrossRef] [PubMed]
17. Chiapasco, M.; Felisati, G.; Maccari, A.; Borloni, R.; Gatti, F.; Di Leo, F. The management of complications following displacement of oral implants in the paranasal sinuses: A multicenter clinical report and proposed treatment protocols. *Int. J. Oral Maxillofac. Surg.* **2009**, *38*, 1273–1278. [CrossRef] [PubMed]
18. Safi, Y.; Mortazavi, H.; Sadeghian, A.; Hazrati, P. Accidental displacement of a dental implant into the nasal cavity: Report of a rare case. *Clin. Case Rep.* **2022**, *10*, e6634. [CrossRef] [PubMed]
19. Cascone, P.; Ungari, C.; Filiaci, F.; Gabriele, G.; Ramieri, V. A dental implant in the anterior cranial fossae. *Int. J. Oral Maxillofac. Surg.* **2010**, *39*, 92–93. [CrossRef]
20. Fernández, H.; Gómez-Delgado, A.; Trujillo-Saldarriaga, S.; Varón-Cardona, D.; Castro-Núñez, J. Zygomatic implants for the management of the severely atrophied maxilla: A retrospective analysis of 244 implants. *J. Oral Maxillofac. Surg.* **2014**, *72*, 887–891. [CrossRef]
21. Loney, W.W., Jr.; Termini, S.; Sisto, J. Plunging ranula formation as a complication of dental implant surgery: A case report. *J. Oral Maxillofac. Surg.* **2006**, *64*, 1204–1208. [CrossRef] [PubMed]
22. Li, K.K.; Varvares, M.A.; Meara, J.G. Descending necrotizing mediastinitis: A complication of dental implant surgery. *Head. Neck.* **1996**, *18*, 192–196. [CrossRef]
23. Kirtay, M.; Yolcu, U.; Dundar, S. Displacement of Dental Implant Into the Submental Space After Surgical Integration. *J. Craniofac. Surg.* **2017**, *28*, e403–e405. [CrossRef]
24. Capecchi, M.; Buongiorno, V.; Romagnoli, A.; Parri, S.N.; Guiducci, G.M.; Bressan, E. Severe descending mediastinitis after routine dental implant surgery: A case report. *Eur. J. Oral Implantol.* **2012**, *5*, 389–396. [PubMed]
25. Boscolo-Rizzo, P.; Da Mosto, M.C. Submandibular space infection: A potentially lethal infection. *Int. J. Infect. Dis.* **2009**, *13*, 327–333. [CrossRef] [PubMed]
26. Miller, C.R.; Von Crowns, K.; Willoughby, V. Fatal Ludwig's Angina: Cases of Lethal Spread of Odontogenic Infection. *Acad. Forensic Pathol.* **2018**, *8*, 150–169. [CrossRef] [PubMed]
27. Colizza, A.; D'Erme, G.; Ciofalo, A.; D'Angeli, G.; Federici, F.R.; Galli, C.; De Vincentiis, M.; Galli, M. Surgical Excision of Unusual Sacked Neck and Mediastinum Abscess of Odontogenic Origin. *Antibiotics* **2022**, *11*, 1757. [CrossRef] [PubMed]
28. Sokouti, M.; Nezafati, S. Descending necrotizing mediastinitis of oropharyngeal infections. *J. Dent. Res. Dent. Clin. Dent. Prospect.* **2009**, *3*, 82–85.
29. Candamourty, R.; Venkatachalam, S.; Babu, M.R.; Kumar, G.S. Ludwig's Angina—An emergency: A case report with literature review. *J. Nat. Sci. Biol. Med.* **2012**, *3*, 206–208. [CrossRef]
30. Gujral, S.; Hughes, J.M.; Wiberg, A. Necrotizing fasciitis. *Eplasty* **2014**, *14*, ic15. [PubMed]
31. Albilia, J.B.; Humber, C.C.; Clokie, C.M.; Sándor, G.K. Lemierre syndrome from an odontogenic source: A review for dentists. *J. Can. Dent. Assoc.* **2010**, *76*, a47.

32. Biasotto, M.; Chiandussi, S.; Costantinides, F.; Di Lenarda, R. Descending necrotizing mediastinitis of odontogenic origin. *Recent Pat. Anti-Infect. Drug Discov.* **2009**, *4*, 143–150. [CrossRef]
33. Sonar, P.R.; Panchbhai, A.; Lande, A.N. Potentially Fatal Ludwig's Angina: A Case Report. *Cureus* **2023**, *15*, e48885. [CrossRef] [PubMed]
34. Exarhos, D.N.; Malagari, K.; Tsatalou, E.G.; Benakis, S.V.; Peppas, C.; Kotanidou, A.; Chondros, D.; Roussos, C. Acute mediastinitis: Spectrum of computed tomography findings. *Eur. Radiol.* **2005**, *15*, 1569–1574. [CrossRef]
35. Belibasakis, G.N.; Charalampakis, G.; Bostanci, N.; Stadlinger, B. Peri-implant infections of oral biofilm etiology. *Adv. Exp. Med. Biol.* **2015**, *830*, 69–84. [PubMed]
36. Mombelli, A.; Lang, N.P. The diagnosis and treatment of peri-implantitis. *Periodontology* **2000**, *1998*, 63–76. [CrossRef]
37. Anil, S.; Aldosari, A.A. Impact of bone quality and implant type on the primary stability: An experimental study using bovine bone. *J. Oral Implantol.* **2015**, *41*, 144–148. [CrossRef]
38. Sennerby, L.; Andersson, P.; Pagliani, L.; Giani, C.; Moretti, G.; Molinari, M.; Motroni, A. Evaluation of a Novel Cone Beam Computed Tomography Scanner for Bone Density Examinations in Preoperative 3D Reconstructions and Correlation with Primary Implant Stability. *Clin. Implant. Dent. Relat. Res.* **2015**, *17*, 844–853. [CrossRef]
39. Faverani, L.P.; Barão, V.A.; Ramalho-Ferreira, G.; Delben, J.A.; Ferreira, M.B.; Garcia Júnior, I.R.; Assunção, W.G. The influence of bone quality on the biomechanical behavior of full-arch implant-supported fixed prostheses. *Mater. Sci. Eng. C Mater. Biol. Appl.* **2014**, *37*, 164–170. [CrossRef]
40. Zhang, Y.; Wang, C.; Zhang, X.; Xu, L. Evaluation of the stress distribution in tooth implant-supported fixed partial prostheses on different bone types under dynamic loads. *Hua Xi Kou Qiang Yi Xue Za Zhi* **2015**, *33*, 286–290. [PubMed]
41. Hansen, B.W.; Ryndin, S.; Mullen, K.M. Infections of Deep Neck Spaces. *Semin. Ultrasound CT MR.* **2020**, *41*, 74–84. [CrossRef]
42. Stein, J.M.; Xian, J. Imaging of Head and Neck Infections. *Neuroimaging Clin. N. Am.* **2023**, *33*, 185–206. [CrossRef] [PubMed]
43. Caprioli, S.; Tagliafico, A.; Fiannacca, M.; Borda, F.; Picasso, R.; Conforti, C.; Casaleggio, A.; Cittadini, G. Imaging assessment of deep neck spaces infections: An anatomical approach. *Radiol. Med.* **2023**, *128*, 81–92. [CrossRef] [PubMed]
44. Crespo, A.N.; Chone, C.T.; Fonseca, A.S.; Montenegro, M.C.; Pereira, R.; Milani, J.A. Clinical versus computed tomography evaluation in the diagnosis and management of deep neck infection. *Sao Paulo Med. J.* **2004**, *122*, 259–263. [CrossRef]
45. Mason, M.E.; Triplett, R.G.; Alfonso, W.F. Life-threatening hemorrhage from placement of a dental implant. *J. Oral Maxillofac. Surg.* **1990**, *48*, 201–204. [CrossRef]
46. Bali, R.K.; Sharma, P.; Gaba, S.; Kaur, A.; Ghanghas, P. A review of complications of odontogenic infections. *Natl. J. Maxillofac. Surg.* **2015**, *6*, 136–143. [CrossRef]
47. Chen, L.; Li, T.; Jing, W.; Tang, W.; Tian, W.; Li, C.; Liu, L. Risk factors of recurrence and life-threatening complications for patients hospitalized with chronic suppurative osteomyelitis of the jaw. *BMC Infect. Dis.* **2013**, *13*, 313. [CrossRef] [PubMed]
48. Ardekian, L.; Dodson, T.B. Complications associated with the placement of dental implants. *Oral Maxillofac. Surg. Clin.* **2003**, *15*, 243–249. [CrossRef] [PubMed]
49. Cariati, P.; Fernandez Solis, J.; Marin Fernandez, A.B.; Valencia-Laseca, A.; Monsalve-Iglesias, F. Accidental displacement of a dental implant into the sublingual space: A case report. *J. Clin. Exp. Dent.* **2016**, *8*, e459–e461. [CrossRef] [PubMed]
50. Tonin, M.H.; Brites, F.C.; Mariano, J.R.; Freitas, K.M.S.; Ortiz, M.A.L.; Salmeron, S. Low-Level Laser and Antimicrobial Photodynamic Therapy Reduce Peri-implantitis-related Microorganisms Grown In Vitro. *Eur. J. Dent.* **2022**, *16*, 161–166. [CrossRef]
51. Rokaya, D.; Srimaneepong, V.; Wisitrasameewon, W.; Humagain, M.; Thunyakitpisal, P. Peri-implantitis Update: Risk Indicators, Diagnosis, and Treatment. *Eur. J. Dent.* **2020**, *14*, 672–682. [CrossRef]
52. Seki, K.; Hasuike, A.; Hagiwara, Y. Clinical Evaluation of the Relationship Between Systemic Disease and the Time of Onset of Peri-Implantitis: A Retrospective Cohort Study. *J. Oral Implantol.* **2023**, *49*, 55–61. [CrossRef] [PubMed]
53. Esposito, M.; Hirsch, J.; Lekholm, U.; Thomsen, P. Differential diagnosis and treatment strategies for biologic complications and failing oral implants: A review of the literature. *Int. J. Oral Maxillofac. Implant.* **1999**, *14*, 473–490.
54. Goodacre, C.J.; Kan, J.Y.; Rungcharassaeng, K. Clinical complications of osseointegrated implants. *J. Prosthet. Dent.* **1999**, *81*, 537–552. [CrossRef]
55. Hemmings, K.W.; Schmitt, A.; Zarb, G.A. Complications and maintenance requirements for fixed prostheses and overdentures in the edentulous mandible: A 5-year report. *Int. J. Oral Maxillofac. Implant.* **1994**, *9*, 191–196.
56. Crovetto-Martínez, R.; Martin-Arregui, F.J.; Zabala-López-de-Maturana, A.; Tudela-Cabello, K.; Crovetto-de la Torre, M.A. Frequency of the odontogenic maxillary sinusitis extended to the anterior ethmoid sinus and response to surgical treatment. *Med. Oral Patol. Oral Cir. Bucal* **2014**, *19*, e409–e413. [CrossRef]
57. Costantinides, F.; Luzzati, R.; Tognetto, D.; Bazzocchi, G.; Biasotto, M.; Tirelli, G.C. Rapidly progressing subperiosteal orbital abscess: An unexpected complication of a group-A streptococcal pharyngitis in a healthy young patient. *Head Face Med.* **2012**, *8*, 28. [CrossRef] [PubMed]
58. Galli, M.; Fusconi, M.; Federici, F.R.; Candelori, F.; De Vincentiis, M.; Polimeni, A.; Testarelli, L.; Cassese, B.; Miccoli, G.; Greco, A. Minimally Invasive Intraoral Approach to Submandibular Lodge. *J. Clin. Med.* **2020**, *9*, 2971. [CrossRef] [PubMed]

59. Manor, Y.; Garfunkel, A.A. Brain abscess following dental implant placement via crestal sinus lift—A case report. *Eur. J. Oral Implantol.* **2018**, *11*, 113–117.
60. Steiner, C.; Bottini, G.B.; Gaggl, A. Brain abscess caused by dental peri-implantitis. *Br. J. Oral Maxillofac. Surg.* **2021**, *59*, 109–110. [CrossRef] [PubMed]
61. Krizek, T.J.; Robson, M.C. Evolution of quantitative bacteriology in wound management. *Am. J. Surg.* **1975**, *130*, 579–584. [CrossRef] [PubMed]
62. Böttger, S.; Zechel-Gran, S.; Schmermund, D.; Streckbein, P.; Wilbrand, J.F.; Knitschke, M.; Pons-Kühnemann, J.; Hain, T.; Weigel, M.; Howaldt, H.P.; et al. Microbiome of Odontogenic Abscesses. *Microorganisms* **2021**, *9*, 1307. [CrossRef]
63. Bagul, R.; Chandan, S.; Sane, V.D.; Patil, S.; Yadav, D. Comparative Evaluation of C-Reactive Protein and WBC Count in Fascial Space Infections of Odontogenic Origin. *J. Maxillofac. Oral Surg.* **2017**, *16*, 238–242. [CrossRef] [PubMed]
64. Safi, Y.; Amid, R.; Zadbin, F.; Ghazizadeh Ahsaie, M.; Mortazavi, H. The occurrence of dental implant malpositioning and related factors: A cross-sectional cone-beam computed tomography survey. *Imaging Sci. Dent.* **2021**, *51*, 251–260. [CrossRef] [PubMed]
65. Givol, N.; Chaushu, G.; Halamish-Shani, T.; Taicher, S. Emergency tracheostomy following life-threatening hemorrhage in the floor of the mouth during immediate implant placement in the mandibular canine region. *J. Periodontol.* **2000**, *71*, 1893–1895. [CrossRef]
66. Pigadas, N.; Simoes, P.; Tuffin, J.R. Massive sublingual haematoma following osseo-integrated implant placement in the anterior mandible. *Br. Dent. J.* **2009**, *206*, 67–68. [CrossRef] [PubMed]
67. Del Castillo-Pardo de Vera, J.L.; López-Arcas Calleja, J.M.; Burgueño-García, M. Hematoma of the floor of the mouth and airway obstruction during mandibular dental implant placement: A case report. *Oral Maxillofac. Surg.* **2008**, *12*, 223–226. [CrossRef]
68. Paradowska-Stolarz, A.; Mikulewicz, M.; Laskowska, J.; Karolewicz, B.; Owczarek, A. The Importance of Chitosan Coatings in Dentistry. *Mar. Drugs* **2023**, *21*, 613. [CrossRef]
69. Egierska, D.; Perszke, M.; Mazur, M.; Duś-Ilnicka, I. Platelet-rich plasma and platelet-rich fibrin in oral surgery: A narrative review. *Dent. Med. Probl.* **2023**, *60*, 177–186. [CrossRef]