

Clinical Outcomes of Acellular Collagen Matrix in Bone Splitting for Alveolar Ridge Reconstruction

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Abstract: *This study presents a case series on the clinical effectiveness of acellular collagen matrix in treating severe atrophy of the alveolar ridge. Using the bone splitting technique, acellular collagen from calf bone was implanted to restore ridge width, while an acellular collagen membrane enhanced gingival width at the ridge crest. Implant restoration was successfully completed, yielding favorable clinical outcomes.*

Keywords: Bone splitting technique, alveolar ridge reconstruction, acellular collagen matrix, implant placement, soft tissue regeneration

1. Introduction

The horizontal atrophy of alveolar bone is usually accompanied by a decrease in the width of the attached gingiva, which not only makes it difficult to implant, but also causes defects in the healthy attachment of the gingiva, leading to peri-implantitis and implantation failure^[1,2]. The success of dental implantation first depends on the long-term and stable synostosis between the implant and the alveolar bone. However, good osseointegration is no longer the only criterion for determining the success of dental implants. Good and healthy attachment gingival closure around the implant is also an important factor affecting its long-term success rate. The absorption of alveolar bone caused by various reasons can also lead to soft tissue defects and reduced attachment gingiva in the implant area^[3-6]. At present, there are methods to solve the horizontal atrophy of the alveolar ridge, such as bone splitting technology, autologous bone transplantation ONLAY bone grafting technology, etc. These techniques for widening the bone width also need to increase the width of the attached gingiva. The main methods to solve the problem of insufficient attached gingiva include autologous free mucosal transplantation and artificial graft attachment gingival widening surgery. This study aims to evaluate the effectiveness of acellular collagen matrix in bone splitting procedures for alveolar ridge reconstruction and its impact on implant success. This research contributes to advancing implantology by demonstrating the benefits of acellular collagen matrix in enhancing alveolar ridge width and soft

tissue regeneration, leading to improved implant success rates.

2. Case selection

The 7 patients included in the study were all implant patients who visited the Stomatology clinic of Beijing Zhongke from January 2021 to December 2024. Inclusion criteria: ① All patients had no contraindications to surgery; ② Before operation, CBCT was taken and the bone width within 2mm of the crest of alveolar ridge was measured by 3 ~ 4mm. ③ Basal bone is obviously wider than alveolar ridge; ④ the usable bone height of alveolar ridge is greater than 10mm; ⑤ The labial side of the missing tooth area has no obvious depression, and the occlusal relationship is normal. ⑥ All patients were informed of the study and signed consent forms.

3. Clinical Cases

We reported a series of 7 cases of knife-edge alveolar ridges (Figure 1a-h) caused by tooth loss and severe alveolar bone resorption. The width of the alveolar ridge crest was approximately 2 - 3 millimeters, and 5 millimeters below the alveolar ridge crest, the width of the alveolar ridge was about 4 - 5 millimeters, with the height of the alveolar ridge being greater than 12 millimeters. These patients had a strong desire for implant restoration. However, the severe insufficiency of bone mass compelled the doctors to consider safe and effective bone augmentation methods to achieve the final implant restoration.



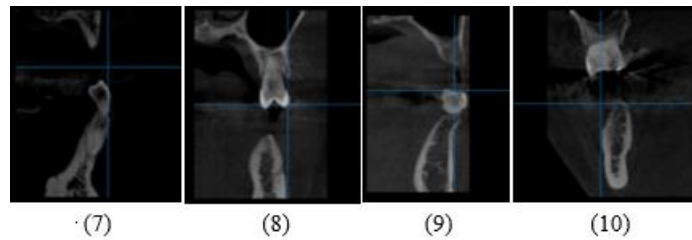


Figure 1: (1) Case 1: Before surgery, #11 and #21 teeth were in preparation; #12 and #13 have missing teeth and severe alveolar ridge resorption; #14 is residual root; (2) Sagittal images show severe atrophy of alveolar ridge; (3) Case 2: The missing teeth #45, #46, and #47 showed obvious alveolar ridge resorption with a width of about 5-8mm; (4) The alveolar ridge was absorbed horizontally and the buccal bone defect was obvious; (5) Case 3: The alveolar ridge of the missing teeth (#13, #12, #11, #21, #22, and #23) was obviously absorbed, and the width of the attached gingiva was significantly reduced; (6) The alveolar ridge was knife-shaped; (7) Case 4: The alveolar ridge absorption at #23 was knife-like; (8) Case 5: #36 Missing teeth, alveolar ridge absorption obvious, knife-like; (9) Case 6: #24 Missing teeth, alveolar ridge absorption obvious, knife-like; (10) Case 7: #46 Missing teeth, the alveolar ridge is knife-shaped, and the widest part of the alveolar ridge is about 4mm.

4. Treatment Procedure

- 1) After local anesthesia, gingival incision, turn up the mucoperiosteal flap, and #14 was minimally invasive removed, completely remove the inflammatory granulation tissue. Exposed the labial bone surface, with obvious depression on the labial side (Figure 2). Ultrasonic bone knife was used to make the osteotomy line of the alveolar crest, and cut through the bone cortex and deep into the bone cancellum to form a guided path of bone splitting. A flat cone bone chisel was used to further increase the width of the gap.
- 2) Implant implantation (Figure 2). After the alveolar ridge is split, prepare the implant socket and adjust the direction of the drill to avoid damage to the labial bone plate and ensure the correct axial orientation of the implant. After the implant socket is implanted at #12 and #14 (3.4×12mm, 4.0×10mm) respectively, the initial stability of the implant is good, reaching 35 Newton, and the implant healing abutment is placed.
- 3) Guide the bone regeneration procedure (Figure 3). In the gap after bone split and implant space especially the lip implanted acellular collagen matrix, surface cover acellular collagen matrix membrane, the membrane to cover the implant surface, at this time, the dry state of acellular collagen matrix membrane, has a certain mechanical strength, convenient pruning, according to the need for easy to operate membrane, convenient to insert the palatal side and labial side of the inner mucous membrane, and have a good support effect.
- 4) Suture (Figure 3). After releasing the flap tension, the gum was sutured without tension, ensuring wound closure. A small part of the extracellular collagen matrix membrane was left exposed to guide cell migration and proliferation.
- 5) Remove stitches (Figure 3). Two weeks later, the sutures were removed and the gums healed. Around the implant has a healthy gingival tissue wrap, and for the health of the qualitative attached gum.



Figure 2: (1) The alveolar labial bone was significantly depressed; (2) The implant is implanted in the alveolar ridge split.

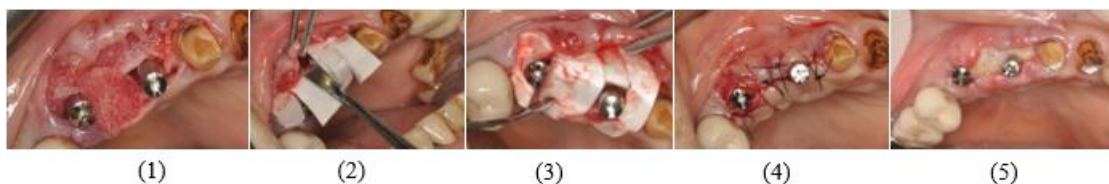


Figure 3: (1) Acellular collagen matrix is implanted around the implant; (2)–(3) Cover the acellular collagen matrix membrane over the implant surface; (4) Close the wound; (5) After two weeks, the gums is healing

- 6) Implant restoration stage (Figure 4). Four months after the operation, the mucosa healed well, and the healing abutment was removed, the gingival cuff was formed, the fullness of the labial alveolar ridge was restored, the width of the attached gingiva was significantly improved, and it could enter the repair and mold stage.
- 7) Final restoration. Finally, the gingival arc and gingival nipple height were reconstructed, the width of the alveolar ridge has increased from the original 3 - 4mm

to 8 - 9mm, basically consistent with the surrounding dentition, and the fullness of the alveolar ridge was also restored (Figure 4), and there was sufficient gingival attachment to ensure the anti-infection ability around the implant. The seven cases of bone splitting have all been successfully followed up for three years. None of the cases developed complications such as peri-implantitis or implant loss.

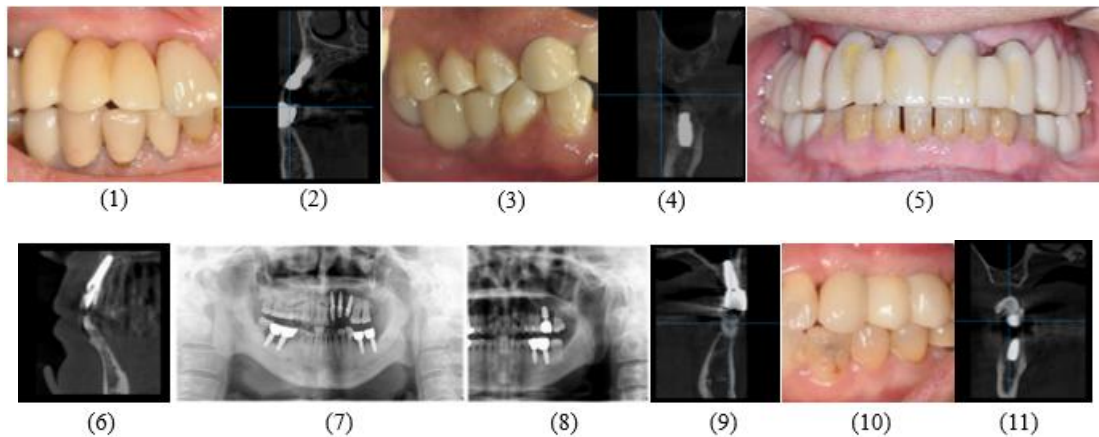


Figure 4: (1) -(2) Case 1: Final repair effect and the implant osseointegration was good; (3) -(4) Case 2: #45 and #47 were reexamined after one year; The implant was integrated with the surrounding bone tissue; (5)-(6) Case 3: The implant osseointegration was good; (7) Case 4: The implant is well integrated with the surrounding tissue; (8) Case 5: #35, #36 The implant osseointegration was good five months after surgery; (9)-(10) Case 6: The implant osseointegration was good; (11) Case 7: A dense autogenous bone was formed around the implant.

5. Discussion

Sufficient width of the alveolar ridge is required to accommodate the implant. The diameter of commonly used implants is usually around 3.3 - 5.0 mm. If the alveolar ridge is too narrow, it will be difficult to place a standard-sized implant. Bone augmentation procedures may be needed or a thinner implant may have to be chosen, and thinner implants may have deficiencies in mechanical strength.

The Importance of the Width of the Attached Gingiva. It ensures the healing of the surgical wound. During implant placement surgery, the attached gingiva with sufficient width adheres closely to the surface of the alveolar ridge, protecting the wound from the invasion of bacteria and other harmful substances. For example, after the surgical incision is sutured, it acts like a barrier, reducing the risk of infection. If the width is too narrow, the surgical field of vision will be limited, increasing the difficulty of surgical operations and easily causing excessive traction and damage to the gingival tissue.

The attached gingiva with a wider width can separate the implant from harmful stimuli in the oral cavity and resist the irritation of the implant's surrounding mucosa caused by plaque, food impaction and so on. Once peri-implantitis occurs, the bone tissue around the implant will gradually be resorbed, affecting the long-term stability of the implant. It can maintain the normal shape and function of the soft tissue around the implant and ensure the integrity of the mucosal seal. A good mucosal seal can prevent liquids and bacteria in

the oral cavity from entering the implant-bone interface, which is beneficial to the long-term stability of the implant.

The key points for successful implantation of acellular matrix in the anterior dental aesthetic area are as follows:

- 1) Selection of indications.
- 2) Surgical techniques: The theoretical basis of bone splitting technique is based on the elastic characteristics of cortical bone, so it is necessary to master appropriate force and angle during surgical operations to avoid excessive or insufficient splitting. Meanwhile, during the splitting process, attention should be paid to protecting the surrounding soft tissues and blood supply to promote postoperative bone healing and implant stability.
- 3) Selection and treatment of decellularized matrix: As a biomaterial, decellularized matrix has good biocompatibility and bone conductivity, which can provide a good bone bonding environment for implants. When selecting decellularized matrix, it is necessary to ensure its reliable source, stable quality, and appropriate treatment and disinfection. In addition, appropriate trimming and shaping should be carried out according to the patient's specific situation and surgical needs before implantation.
- 4) The selection and implantation of implants.
- 5) Postoperative care and follow-up: Postoperative care and follow-up are equally crucial for successful implantation. Following surgery, patients should receive antibiotics and pain management medications while being educated on post-operative care and oral hygiene.

Regular follow-ups are essential to detect and address potential complications.

Through the above cases, it can be seen that missing teeth can cause obvious resorption of alveolar ridge, forming unfavorable bone defects, resulting in poor effect of surgical bone increment to guide bone regeneration. To achieve good bone regeneration, alveolar ridge cleavage has good predictability and has the following advantages: avoiding horizontal to massive autologous bone grafting. During the same period of implant implantation, the bone healing period and the implant healing period overlap, reducing the number of operations, shortening the treatment period and reducing patient discomfort. After splitting the alveolar ridge and inserting the implant, there is a bone plate on both the labial and palatal side of the implant, transforming the unfavorable bone defect into a favorable bone defect. Therefore, we need to implant osteogenic materials in the larger cleaved bone space to ensure that new lamellar bone can form in the future. Implant materials used in this case, Decellular collagen matrix filling materials and Decellular collagen matrix plasma membrane are acellular matrix products, has good biocompatibility, after special treatment, remove the immunogen components, retained the natural biological active ingredients, so can be compatible with human tissue at the same time also has a powerful endogenous tissue induction ability. Decellular matrix can induce cell adhesion and growth, and accelerate the tissue repair process^[7-12]. The safety and effectiveness of this product was confirmed by the good tissue regeneration effect of this case, which deserves clinical use.

With the increasing application of implant restoration techniques in clinical practice, more attention has been paid to the soft tissue around the implant. Widening of the attached gingiva helps to prevent peri-implantitis and contributes to the long-term success of implant repair^[13,14,17]. Attached gingival widening mainly adopts three methods: pedicled flap, free gingival transplantation and artificial graft. Free gingival grafting technique has a high sensitivity and a risk of graft necrosis. Therefore, finding new technologies to promote the regeneration of periimplant attached gums, reduce surgical complications, and prevent and treat peri-implantitis are still the topics being explored by scholars from all over the world^[15,16,18].

6. Conclusion

The combination of bone splitting techniques with acellular collagen matrix is an effective approach to overcoming alveolar ridge width deficiencies. This method supports both bone and gingival regeneration, ensuring improved implant stability. Acellular collagen matrix simplifies procedures, reduces post-operative complications, and demonstrates strong clinical potential for future use in dental implantology.

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