Clinical Report

Esthetic Effects of Immediate Implantation and Restoration after Minimally Invasive Tooth Extraction on Maxillary Central Incisors

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Abstract: We aimed to evaluate the esthetic effects of immediate implantation and restoration after minimally invasive tooth extraction on maxillary central incisors, and the influence on the reconstruction of labial bone lamella. From January 2014 to September 2018, 108 patients who underwent minimally invasive tooth extraction, implantation and restoration due to residual crown of a single maxillary central incisor in our hospital were divided into three groups according to different treatment methods. Group A (n=41) received delayed implantation and immediate restoration, group B (n=32) underwent immediate implantation and delayed restoration, and group C (n=35) was subjected to immediate implantation and restoration. On the day of restoration and 1 year later, the esthetic effects were assessed by using white esthetic index and pink esthetic index (PES). One year after restoration, the degree of satisfaction was evaluated with the visual analog scale. The implantation success rate and 1-year retention rate of the three groups all reached 100.00%. On the day of restoration and 1 year later, the PES values of groups A, B, and C followed an ascending order, with significant intergroup differences (P<0.05). The values of the three groups 1 year after restoration were significantly higher than those on the day of restoration (P<0.05). Group C was significantly more satisfactory about the overall esthetics, height of attachment and chewing function than groups A and B (P<0.05). Immediate implantation and restoration after minimally invasive tooth extraction can significantly promote the early induction of gingival reshaping, improve the esthetics of soft tissue around the implant, and augment patients’ satisfaction.

Key words: Immediate, Implantation, Restoration, Maxillary central incisor, Esthetic effect

Introduction

Residual crown of the maxillary central incisor (MCI), as a common injury in the esthetic area of anterior teeth, is mostly treated by implantation and restoration. It is traditionally held that the best time for dental implant is at 3-4 months after tooth extraction when the wound is completely healed. However, this method suffers from obvious absorption of alveolar bone, especially the labial bone lamella, secondary gingival papillary defects as well as labial soft tissue collapse, reducing patients’ satisfaction. In recent years, minimally invasive techniques have been continuously developed. Placing an implant into a fresh extraction socket with unhealed hard and soft tissues after tooth extraction is referred to as immediate implantation. This strategy can effectively shorten the treatment time, and prevent alveolar bone resorption and gingival papillary defects. In contrast, it has previously been reported that the soft and hard tissue structures of the extraction socket were unstable, so unpredictable changes occurred during tissue healing. Besides, the combination of an implant with patient’s own tissue is different from that of natural teeth. The gingival morphology changes after restoration, causing unsatisfactory pink esthetic effects. Therefore, gingival repair has been highlighted in the field of restoration esthetics after oral implantation. At present, delayed temporary repair is preferred to immediate temporary repair in clinical practice. However, the toothless period is still troublesome. In this study, the esthetic effects of minimally invasive delayed implantation-immediate restoration, immediate implantation-delayed restoration, and immediate implantation-immediate restoration on MCI were compared.

Materials and Methods

Baseline clinical data

A total of 108 patients who underwent minimally invasive tooth extraction, implantation and restoration due to residual crown of a single MCI in our hospital from January 2014 to September 2018 were selected, including 63 males and 45 females aged 22-57 years old, with an average of (38.62 ± 3.91). They were divided into three groups according to different treatment methods. Group A (n=41) received delayed implantation and immediate restoration, group B (n=32) underwent immediate implantation and delayed restoration, and group C (n=35) was subjected to immediate implantation and restoration. Inclusion criteria: 1) Patients who underwent minimally invasive tooth extraction, implantation and restoration owing to residual crown of a single MCI; those without defects or loss of the alveolar bone and labial bone lamella; those with the buccolingual width of 7-8 mm, available bone height of >15 mm, complete alveolar socket, extraction socket bottom of >3 mm away from the nasal base, complete soft tissues, width of attached gingiva of >2 mm and normal occluding relationship; those who were physically and psychologically healthy without other diseases and contraindications to implantation surgery; those with complete clinical and follow-up data; those with written informed consents. Exclusion criteria: Patients with poor oral hygiene and compliance; those allergic to the
materials and drugs used in this study; those with obvious inflammation of soft tissues around the teeth; those with a habit of clenching or grinding their teeth; those with unsatisfactory position and angle of tooth root. This study was reviewed and approved by the Medical Ethics Committee of Beijing Tongren Hospital (approval No. BTH201401003).

Selection of surgical methods
Before surgery, the patients were examined for liver and kidney function, blood and urine routine and blood rheology. CT was performed to detect the condition of the alveolar bone and surrounding tissues at the implantation site. A plaster model was established to determine the implant length, diameter and surgical plan. Site preservation and delayed implantation were adopted for those without good initial stability due to insufficient root or labial bone mass or acute inflammation in extraction sockets. Immediate implantation was employed for those with abundant soft and hard tissues in the extraction socket without obvious infections, and sufficient root bone mass and intact labial bone lamella. Immediate restoration was used for those who did not receive guided bone regeneration (GBR) due to bone defect or the initial stability of the implant ≥35 N cm after consent. Delayed restoration was used for those who received GBR or the initial stability of the implant <35 N cm. Before surgery, total periodontal scaling was performed to remove calculus and soft dirt, keeping the mouth clean.

Minimally invasive tooth extraction
After local anesthesia with articaine hydrochloride and epinephrine tartrate injection (Produits Dentaires Pierre Rolland, Mérignac, France), the maxillofacial area was routinely sterilized and draped under aseptic conditions. A minimally invasive dental extraction knife (Original Luxator, Direta, Sweden) was carefully inserted into the periodontal membrane space, clinging closely to the root surface of the affected tooth. The periodontal membrane tissue and the gingiva around the root were cut off in the order of mesial, distal, labial and lingual side of the affected tooth. After the root was completely loosened, the dislocated tooth was slowly removed using the needle holder or root forceps, and the soft and hard tissues around the affected tooth should be kept intact as far as possible. The periodontal membrane tissue, granulation tissue and residual debris of the alveolar socket were removed clean, and rinsed repeatedly with sodium chloride injection (Sichuan Kelun Pharmaceutical Co., Ltd., Chengdu, China) and 3% hydrogen peroxide solution (Guangdong Nanguo Pharmaceutical Co., Ltd., Zhanjiang, China). To ensure the integrity of the labial bone wall, the damage of the labial bone lamella was explored using periodontal probes.

Implant placement
ITI soft tissue horizontal implants (Institut Straumann AG, Basel, Switzerland) were used. The implantation position and direction for patients receiving immediate implantation were determined based on the size of extraction socket, distance between adjacent teeth and quality of the alveolar bone in the edentulous area. The expanding drill should be leaned towards the palatal side to prevent damage to the labial bone lamella. During the drilling, the cavity was prepared step by step, and implants with appropriate root shape, length and diameter were implanted. The bone implantation could not be performed in the case of jumping space of 1-2 mm, and the artificial bone (Engineering Research Center in Biomaterials, Sichuan University, Chengdu, China) could be implanted in the case of jumping space >2 mm at 2-3 mm beyond the bottom of the alveolar socket, in which the crown of the implant was 1-3 mm below the alveolar crest, and the implantation torque was greater than 30 N cm. If the gap between the implant and the remaining bone wall around the socket was greater than 1 mm, it was needed to screw in a sealing screw and fill with Bio-Oss bone powders (Geistlich Biomaterials, Wolhusen, Switzerland). The implant was routinely implanted at 90 days after minimally invasive tooth extraction for the patients receiving delayed implantation under the conditions of complete healing of tooth extraction, smooth extraction socket and recovery of alveolar bone. A trapezoidal incision was made at the labial side 3 mm away from the alveolar crest, and a transverse incision was made at the top of the alveolar crest, in which the gingiva was sharply separated, and the edge was sutured to avoid mucosal injury. A round bur was used to localize at the palatal side, and the implantation torque was 35-50 N cm. The remaining steps were the same as those in immediate implantation.

Restoration methods
For patients receiving immediate restoration, the temporary abutment was installed at the time of immediate implantation, and a suitable height and angle was adjusted. The self-curing resin was used to make a temporary restoration body on the adjusted temporary abutment to induce gingival formation. The occluding relation was adjusted to avoid occlusal contact. The patients were instructed to review regularly, and the adjacent surface and neck of the temporary restoration body were adjusted promptly to ensure that the soft tissues around the implant were induced into the natural transition zone and gingival contour. For patients receiving delayed restoration, it was needed to implant the healing abutment immediately after implantation. After 3 months when the soft and hard tissues around the implant were healed and stable well, the healing abutment was removed, and the temporary abutment was installed. The remaining steps were the same as those of immediate restoration. All patients were examined after 3 months, and X-ray periapical film was used to check the implant bone fusion and healing of surrounding soft tissues, which ensured the stability of gingival tissues. Silicone rubber was used for impression, the plaster model was poured, and the individualized abutment and final restoration body were prepared, finally realizing permanent restoration.

Determination criteria for successful implantation
The efficacy was evaluated by the criteria proposed by Albrektsson et al.6: Non-transmission areas around the implant are found by X-ray examination. The implant has no clinical mobility during exercise. The surrounding mucosa and soft tissues are healthy. One year after repair, the annual resorption of vertical bone is less than 0.2 mm. There are no numbness, pain, infection and foreign body sensation after implantation, and no irreversible and/or continuous injury of the nasal fundus, maxillary sinus and mandibular canal.

Evaluation criteria for esthetic indices
On the day of restoration and 1 year after restoration, the esthetic effect of dental implant crowns was evaluated by white esthetic index (WES)7, including 5 items (crown outline, shape, color, texture and transparency), 0-2 points for each item, with a total score of 10 points. The esthetic effect of soft tissues around the implant was evaluated using the pink esthetic index (PES)8, including 7 items (soft tissue texture, morphology and color, mesial gingival papilla, distal gingival papilla, marginal gingival level and alveolar appearance), 0-2 points for each item, with a total score of 14 points. A higher score means better esthetics.
Scoring of satisfaction degree

One year after restoration, the patients’ satisfaction was assessed by the visual analog scale (VAS)⁹, including 4 items (surrounding soft tissue color, overall esthetics, attachment height and masticatory function). A 10 cm-long straight line was drawn using a ruler on the paper, and marked 1 point every 1 cm, 0 point and 10 points on the left and right ends, respectively. The patients gave the score according to their own evaluation. The total score is 40 points, and a higher score means that the patient is more satisfactory.

Statistical analysis

All data were statistically analyzed by SPSS 18.0 software (SPSS Inc., Chicago, MI, USA). The numerical data were expressed as percentage [n (%)] and subjected to the χ² test. The quantitative data were represented as (mean ± standard deviation). Multigroup comparisons at the same time point were performed by one-way analysis of variance, and those at different time points were conducted with the repeated measures analysis of variance. Intragroup comparisons at different time points were carried out by the paired t test, and intergroup comparisons at the same time point were performed with the q test. P<0.05 was considered statistically significant.

Results

Basic treatment outcomes

The implantation success rate and 1-year retention rate of the three groups all reached 100.00%.

Esthetic indices

The three groups had similar WES values on the day of restoration and 1 year later (P>0.05). On the day of restoration and 1 year later, the PES values of groups A, B, and C followed an ascending order, with significant intergroup differences (P<0.05). The values of the three groups 1 year after restoration were significantly higher than those on the day of restoration (P<0.05) (Table 1).

Degree of satisfaction

The three groups were similarly satisfactory about the color (P>0.05). Group C was significantly more satisfactory about the overall esthetics, height of attachment and chewing function than groups A and B (P<0.05) (Table 2). The tooth photographs of a case in Group C before surgery, on the day of restoration and 1 year later are presented in Fig. 1.

Table 1. WES and PES values

| Item                  | Group A (n=41) | Group B (n=32) | Group C (n=35) | F     | P     |
|-----------------------|----------------|----------------|----------------|-------|-------|
| WES (point)           |                |                |                |       |       |
| On the day of restoration | 8.23±0.86     | 8.16±0.87      | 8.41±0.95      | 0.965 | 0.372 |
| 1 year after restoration | 8.28±0.85     | 8.39±0.93      | 8.57±1.03      | 1.218 | 0.164 |
| PES (point)           |                |                |                |       |       |
| On the day of restoration | 8.17±0.89     | 9.28±1.15      | 10.68±1.24     | 8.239 | 0     |
| 1 year after restoration | 9.92±1.06     | 11.34±1.26    | 12.95±1.37     | 6.857 | 0     |

Compared with group A, *P<0.05; compared with group B, †P<0.05; compared with the data on the day of restoration, *P<0.05.

Table 2. Degree of satisfaction

| Item                  | Group A (n=41) | Group B (n=32) | Group C (n=35) | F     | P     |
|-----------------------|----------------|----------------|----------------|-------|-------|
| Color                 | 8.67±0.92      | 8.73±0.94      | 8.69±0.93      | 0.995 | 0.946 |
| Overall esthetics     | 7.93±0.85      | 7.86±0.82      | 9.07±1.05      | 5.631 | 0     |
| Attachment height     | 6.81±0.74      | 6.95±0.71      | 8.98±0.96      | 9.458 | 0     |
| Chewing function      | 7.04±0.81      | 7.12±0.80      | 8.79±0.88      | 8.012 | 0     |

Compared with group A, *P<0.05; compared with group B, †P<0.05.

Figure 1. Tooth photographs of a 36-year-old male in Group C before surgery (a), on the day of restoration (b) and 1 year later (c). He injured the upper right central incisor during work. This oblique fracture was 5 mm from the lingual side to the subgingival area, which cannot be preserved through crown length or orthodontic treatment. After extraction, immediate implantation and restoration were performed.
Discussion

The esthetic implant restoration technology, as an important means of treating dentition defects, can not only restore the normal function of teeth, repair the oral cavity, and keep it stable for a long time, but also achieve an ideal esthetic effect. Tooth extraction is the first step of treatment. With the improvement of medical technology and devices, minimally invasive tooth extraction has become the most commonly used method. Compared with traditional tooth extraction, this method has less surgical trauma, greatly reduces the damage to soft tissue and bone tissue, maximizes the retention of attached gingival and bone tissue, forms a good biological seal around the implant neck, improves the initial stability of the implant, and achieves an ideal esthetic effect\(^1\). However, it has been reported in many literatures\(^2\) that after the loss of teeth in the esthetic area, the soft and hard tissues of the alveolar ridge will be reconstructed, and the alveolar bone will be absorbed, with the vertical absorption reaching 0.4 to 3.9 mm and the horizontal absorption reaching 2.6 to 4.6 mm. In addition, the labiobuccal bone plates are also obviously absorbed by accompanying soft tissue collapse and gingival papilla defect or even loss. Therefore, it is crucial to choose the proper implant placement and restoration time after tooth extraction. Immediate implantation and immediate repair can greatly shorten the treatment time and rehabilitation process of patients, significantly improve the denture function and esthetic effect and the satisfaction of patients\(^3\). In this study, the success rate of implantation and the survival rate of implants of the patients in the three groups all reached 100.00 percent after one year of restoration, indicating that after minimally invasive tooth extraction, the implantation and restoration time selected according to the patients’ own conditions achieved good therapeutic effects.

The three groups had similar WES values on the day of restoration and 1 year later (P>0.05), suggesting that different implantation and restoration time has no effect on WES of the implant crown. To improve the effect of the esthetic area, patients are often given personalized gingival induction to obtain the optimal gingival profile and transition zone shape. On the day of repair and one year after repair, the PES values of groups A, B and C increased sequentially, with the difference statistically significant in pairwise comparison (P<0.05). PES one year after repair of the three groups was significantly higher than that of the day after repair (P<0.05). Immediate implantation and immediate repair after minimally invasive tooth extraction can effectively restore the distal and proximal gingival papilla, texture, shape and color of soft tissue, marginal gingival level and the shape of the alveolar bone around the implant, thereby improving PES of the gingiva. For the patients with immediate implantation and delayed repair, the soft and hard tissue in the extraction socket was abundant after minimally invasive tooth extraction, with no obvious infection. For the patients with delayed implantation and immediate repair, extraction socket was accompanied by acute inflammation, with insufficient root or labial bone mass, so delayed implantation was performed, but the implant had better initial stability and immediate repair was performed. Temporary prostheses were used immediately after the immediate repair, and finished healing abutments were installed immediately after the delayed repair. Temporary prostheses not only restore the pronunciation and esthetics immediately after surgery, but also induce the surrounding soft tissue to form a good gingival contour through modification\(^4\). Although the immediate implantation and delayed restoration was adopted in group B, the soft and hard tissues of the patients were abundant, with no obvious infection, the bone mass was sufficient and complete, and only the initial stability of the implant was small. Therefore, the overall gingival PES was significantly better than that of the patients with delayed implantation and immediate repair. With the growth and recovery of soft and hard tissues, the gingival PES of the three groups was further improved one year after repair. There was no significant difference in the color satisfaction score among the three groups (P>0.05), indicating that the color of the surrounding soft tissues recovered significantly one year after repair. The overall esthetics, attachment height, and masticatory function satisfaction of group C were significantly higher than those of groups A and B (P<0.05), probably because immediate implantation and immediate restoration can prevent the soft and hard tissues in the edentulous area from being damaged by repeated operations and facilitate the recovery.

In summary, the immediate implantation and repair of a single maxillary central incisor with minimally invasive tooth extraction in the esthetic area can significantly promote the early induction of gingival shaping, improve the esthetic effect of the soft tissue around the implant, and improve patient satisfaction. Hence, it has become the first choice of treatment for patients with maxillary central incisor in the esthetic area. Nevertheless, due to individual differences and limitations of the actual situation, patients still need to choose the treatment plan carefully according to their own conditions.

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Competing Interests

The authors declare that they have no competing interests.

References

1. Griggs JA. Dental implants. Dent Clin North Am 61: 857-871, 2017
2. Liu D, Shi L, Dai X, Zhou Q, Yang F, Shen M, Yu Y and Wu Y. Implants placed simultaneously with maxillary sinus floor augmentation in the presence of antral pseudocysts: Presentation of a case series. Quintessence Int 49: 479-485, 2018
3. Zafar K, Ghafoor R, Khan FR and Hameed MH. Awareness of dentists regarding immediate management of dental avulsion: Knowledge, attitude, and practice study. J Pak Med Assoc 68: 595-599, 2018
4. Vinothkumar TS, Kandaswamy D, Arathi G, Ramkumar S and Fel-sypremila G. Endodontic management of dilacerated maxillary central incisor fused to a supernumerary tooth using cone beam computed tomography: An unusual clinical presentation. J Contemp Dent Pract 18: 522-526, 2017
5. Felice P, Zucchelli G, Cannizzaro G, Barausse C, Diazza M, Trul-lenque-Eriksson A and Esposito M. Immediate, immediate-delayed (6 weeks) and delayed (4 months) post-extractive single implants: 4-month post-loading data from a randomised controlled trial. Eur J Oral Implantol 9: 233-247, 2016
6. Albrektsson T and Wennberg A. The impact of oral implants-past and future, 1966-2042. J Can Dent Assoc 71: 327, 2005
7. Tian J, Di P, Lin Y, Zhang Y, Wei DH and Cui HY. A pilot clinical study of immediate provisionalization with a chairside computer aided design and computer aided manufacture monolithic crown for single tooth immediate implant placement. Zhonghua Kou Qiang Yi Xue Za Zhi 52: 3-9, 2017
8. Parthasarathy H, Ramachandran T, Tadepalli A and Ponnaiyan D. Staged hard and soft tissue reconstruction followed by implant supported restoration in the esthetic zone: A case report. J Clin Diagn Res 11: ZD06, 2017
9. den Hartog L, Meijer HJ, Santiing HJ, Vissink A and Raghoebear GM. Patient satisfaction with single-tooth implant therapy in the es-
Mingyu Song: Implantation and Restoration after Tooth Extraction

10. Nepal P, Mori S, Kita Y, Tanabe K, Baba K, Sasaki F, Nasu Y, Ido A, Uchikado Y, Kurahara H and Ariagami T. Combined endoscopic sub-mucosal dissection and transanal minimally invasive surgery for the management of lower rectal adenoma extending above the dentate line: A case report. Medicine 98: e15289, 2019

11. Luo H, Qi X, Shi H, Zhao H, Liu C, Chen H, Peng R, Yu Z, Hu K, Wang C and Li X. Single-dose del nido cardioplegia used in adult minimally invasive valve surgery. J Thorac Dis 11: 2373, 2019

12. Rieder D, Eggert J, Krafft T, Weber HP, Wichmann MG and Heckmann SM. Impact of placement and restoration timing on single-implant esthetic outcome—A randomized clinical trial. Clin Oral Implant Res 27: e80-86, 2016

13. Kuchler U, Chappuis V, Gruber R, Lang NP and Salvi GE. Immediate implant placement with simultaneous guided bone regeneration in the esthetic zone: 10-year clinical and radiographic outcomes. Clin Oral Implants Res 27: 253-257, 2016
