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Evaluation of Implant Rehabilitation in the Maxilla Using Split Crest Technique

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Objective: This study aimed to compare and assess treatment success according to the type of prosthetic restoration among patients undergoing simultaneous implant insertion in the maxilla with the split crest technique.

Materials and Methods: This retrospective study included 19 patients aged 39–72 years old. The patients received implant surgery using the split crest technique followed by rehabilitation with either fixed or removable implant-supported prostheses due to insufficient alveolar width in the maxilla. The patients were divided into two groups, fixed (Group 1) and removable (overdenture) (Group 2). A total of 31 implants were placed in 10 patients in Group 1 and 36 implants in 9 patients in Group 2, for a sum of 67 implants. Clinical findings including implant survival rate, prosthetic complications, and implant success rate were recorded from patient follow-up files. Radiographic records were used to assess marginal bone loss.

Results: Marginal bone loss was greater in Group 2 than Group 1. However, both groups were similar in terms of prosthetic complications, implant failure, and implant success rate. Furthermore, marginal bone loss was greater among patients with prosthetic complications.

Conclusions: Simultaneous implant insertion with the split crest technique in the maxilla may be an effective technique. However, it should be noted that implant-supported overdenture prostheses may cause a greater amount of marginal bone loss compared to fixed prostheses.

***Key words**: Implant-supported dental prosthesis, maxilla, alveolar bone loss*

Üst Çenede Split Kret Tekniği Kullanilarak Yapilan Implant Tedavisinin Değerlendirilmesi

Amaç: Bu çalışmanın amacı, üst çenede split kret tekniği ile aynı anda implant uygulanan hastalarda tedavideki başarının protetik restorasyon tipine göre karşılaştırılması ve değerlendirilmesidir.

Gereç ve Yöntem: Bu restrospektif çalışmaya yaşları 39-72 arasında değişen 19 hasta dahil edilmiştir. Maksillada yetersiz alveolar genişliği olan hastalara split kret tedavisi ile implant cerrahisi uygulanmış ve daha sonra protetik restorasyonu yapılmıştır. Hastalar uygulanan protez tipine göre sabit (Grup 1) veya hareketli (overdenture) (Grup 2) olarak 2 gruba ayrılmıştır. Grup 1' deki 10 hastaya 31 adet, Grup 2' deki 9 hastaya 36 adet olmak üzere toplam 67 adet implant uygulanmıştır. Hasta takip dosyalarından elde edilen klinik bulgular olan implant sağ-kalım oranı, protetik komplikasyon varlığı ve implant başarı oranı değerlendirilmiştir. Radyografik kayıtlardan ise marjinal kemik kaybı değerlendirilmiştir.

Bulgular: Çalışmamızda Grup 2'deki marjinal kemik kaybı miktarı Grup 1 den yüksek bulunmuştur. Bununla birlikte protetik komplikasyon, implant kaybı ve implant başarı oranı açısından her iki grupta benzer sonuçlar elde edilmiştir. Ayrıca protetik komplikasyonların gözlendiği hastalarda marjinal kemik kaybının da yüksek olduğu belirlenmiştir.

Sonuçlar: Üst çenede split kret tekniği ile aynı anda implant uygulama başarılı bir yöntem olarak kullanılabilir. Ancak implant destekli overdenture protezlerde sabit proteze göre daha fazla marjinal kemik kaybı oluşabileceği göz önünde bulundurulmalıdır.

***Anahtar Kelimeler:** İmplant-destekli diş protezi, maksilla, alveoler kemik kaybi*

Introduction

Effective oral rehabilitation is important for preserving bone volume in implant procedures. A relevant horizontal deficit of the alveolar ridge may render the use of dental implants difficult or impossible (1, 2). In the case of horizontal reduction in the edentulous ridge, a number of techniques including autogenous onlay bone grafts, oriented bone regeneration, and alveolar distraction osteogenesis can be used (2–6). In cases in which autogenous grafts are performed, presentation of second surgical site increases the risk of postoperative morbidity (4, 5, 7). The oriented bone regeneration technique, on one hand, is characterized by a longer healing period and the grafts and membranes used in healing phase may be exposed and lead to bone tissue and implant failure (2, 5). In distraction osteogenesis, on the other hand, the disadvantages include a prolonged treatment process and bone resorption. Therefore, the split crest technique has been developed as it offers suitability to application of simultaneous implant in the case of alveolar atrophy in the horizontal direction without the need for a second surgical site thus providing reduced level of postoperative morbidity (2–4). In this

technique, an incision is made on the sagittal direction in the outer layer of an alveolar crest and stretched in the buccal direction while an implant is placed simultaneously (2, 8).

The main objective of implant procedures is to eliminate toothlessness with implant-supported prostheses of osseointegrated implants (9). The impairments in function, phonation, aesthetics, and overall mouth health by either partial or complete tooth loss in patients can be restored either with fixed or removable implant-supported prostheses (10).

Despite the advantages provided by implant-supported prostheses, some clinical complications may occur in these restorations (11, 12). Clinical studies have shown that the type, frequency, and recurrence of complications vary by the type of prostheses (fixed or removable) (13). Complications may arise in implant-supported overdenture prostheses mainly due to functional effects such as biological (failure of osseointegration, mucositis, or periimplantitis) and biomechanical (bar fracture, loss of retaining ability of retainer clips, or prosthesis fracture) factors (11, 14). Results from a five-year clinical follow-up of patients who underwent implant-supported fixed prosthesis implantation involved complications resulting from loose screws, screw fracture, veneer-porcelain fracture, and infrastructure fracture (15). Therefore, the type of implant-supported restoration becomes important in the success of implant therapy.

There is no data in the literature with a sufficiently long-term follow-up and making comparison on the effectiveness of dental implant therapy utilizing different prosthesis techniques where alveolar crest expansion was performed by alveolar split osteotomy. Hence, the aim of the present study was to compare the efficacy of simultaneous implant placement with the split crest technique in the maxilla with regard to the type of implant-supported prostheses (fixed or removable).

Materials and Methods

This study included patients who presented to the Karadeniz Technical University Faculty of Dentistry departments of Maxillofacial Surgery and Prosthodontics between 2012 and 2017 with the absence of a tooth in the maxillary region. The patients underwent implant surgery with the split crest technique due to inadequate alveolar width (2–3.5 mm) followed by prosthetic rehabilitation and a minimum one-year follow-up. The demographic data, clinical and radiological records of these patients are retrospectively analyzed from patient's follow-up files and computer database. Patients with systemic disorders that would impact treatment outcomes (diabetes, osteoporosis, etc.), parafunctional habits, smoking addiction, untreated periodontal disorders, history of augmentation or implant surgery at the same site, or pathological conditions in the soft or hard tissues were excluded.

This study was approved by the Karadeniz Technical University Faculty of Medicine Scientific Research Ethics Committee (Protocol No: 2019/120). All patients were informed regarding the risks, benefits, and potential outcomes of the treatment protocol and provided written informed consent. The patients were divided into two groups by treatment modality.

Group 1 (fixed prosthesis group): This group of patients underwent implant surgery using the split crest technique with the upper structure completed as a fixed prosthesis after clinical and radiological evaluation.

Group 2 (removable prosthesis group): This group of patients underwent implant surgery using the split crest technique with the upper structure completed as a removable prosthesis.

The present investigation included a total of 19 patients treated with implant therapy using the crest split technique. Group 1 included 10 patients (6 women and 4 men; mean age 53.50 years) and Group 2 included 9 patients (7 women and 2 men; mean age 57.44 years). A total of 31 implants were inserted into the patients in Group 1 and 36 implants into the patients in Group 2 for a sum of 67 implants. The mean follow-up period was 29.20 months in Group 1 and 31.22 months in Group 2.

All patients in this group were rehabilitated with implant-supported bar-retained overdentures. The clinical and prosthetic records accessed from patient files were assessed. The clinical data were used to categorize patients as implant failure present or implant failure absent. Implant success rate among patients was coded as 1 if no biological or prosthetic complication occurred during the follow-up period and 0 if any complications occurred (16). The radiological records were used to assess marginal bone loss. Using the acquired x-ray records, the latter was quantified in mm with a panoramic radiography device available at our university (Kodak 9000C; Kodak Dental Systems, Carestream Health, Rochester, NY, USA). In all cases, the distance between the implant reference point (the peak neck region) and bone layer in the mesial and distal region was measured and averaged over panoramic radiograms obtained with the same calibrated radiographic images using the same technique. This distance was regarded as "0" because all the implants were placed at the bone level. Additionally, demographic data potentially affecting study results (age, follow-up period, and gender) were also assessed.

Surgical Protocol: All procedures involving implant surgery were performed by the same surgeon. After local anesthesia, crestal incisions were made to elevate a full-thickness flap. Vertical incisions were made to relieve the flap distally and mesially to the incision. Then, the mucoperiosteal flap was elevated (Figure 1A). To ensure the thin alveolar bone would not be fractured at the location of the split a mid-crestal opening osteotomy was performed using a scalpel. The osteotomy line was deepened with the scalpel and the outer alveolar cortex was stretched and freed using the

scalpel like an osteotome (Figure 1B). This was followed by the expansion of the alveolus using sharp osteotomes as necessary. After the cortical bone was expanded, osteotomies for the implant installation were achieved using the initial drill to determine the depth and direction of the site. The bone expansion was performed and the implants were placed into cancellous bone without saline irrigation to achieve primary stability (Figure 1C). The autogenous grafts obtained from the osteotomy region were mixed with the allograft (small granules 0.25–1 mm, Maxxeus Dental, OH, USA) and the spaces formed with the mixed grafts between the cortices of the stretched alveolar crest and around the implants. Then, the area of operation was sutured with 3–0 vicryl sutures. The patients were prescribed amoxicillin 500 mg 3x1 and flurbiprofen 100 mg 2x1 for five days and 0.2% chlorhexidine digluconate 2x1 for one week. The patients were also prescribed standard recommendations postoperatively and the sutures were removed 10 days later.

Figure 1. **A**. Pre-operative image of horizontal deficit of the alveolar ridge. **B**. Clinical intra-operative image of alveolar expansion by split crest technique. **C**.Simultaneous implant placement after crest expansion

A mean time of 5 months (range 4–6) was allowed for osseointegration, followed by the installation of healing caps. After the healing period, the patients received either fixed or removable implant-supported prostheses depending on patient needs. The patients were followed-up for at least one year.

Statistical Analysis: Statistical analyses were performed by using SPPS for Windows 17.0 (SPSS Inc., Chicago, IL, USA). The Mann Whitney U, Chi-square and Spearmen correlation tests were used for the statistical comparisons. The confidence level was set as 95%.

Results

The mean age, follow-up period, and gender distribution of participants did not differ significantly among groups (P>0.05). The two groups significantly differed only with respect to the number of implants (P<0.05) (Table 1).

Table 2 summarizes the comparison of the treatment results between the groups. A total of 4 (5%) implants were lost, yielding an implant survival rate of 95%. Four implant failures occurred in Group 2. The overall survival rate was 88.8% for this group of patients. No implant failure occurred in Group 1 after implant placement with a survival rate of 100%. However, no significant difference was found between the two groups with regard to the rate of implant failure (P>0.05).

Table 1. Study variables and descriptive statistics

	Grup 1 (n=10 patients)	Grup 2 (n=9 patients)	P-value
Gender, n (%)			
Women	6 (60.0)	7 (77.8)	0.370
Men	4 (40.0)	2 (22.2)	
Age (year)	53.50±9.58 (43-68)	57.44±10.07 (39-72)	0.414
Follow-up period (month)	29.20±16.95 (12-60)	31.22±23.33 (12-68)	0.805
Number of implants, n(%)	31 (46)	36 (54)	0.005*

Note: Data are presented as mean±standard deviation (minimum-maximum)

* There were significant differences between the groups in number of implants (P<0.05)

Table 2. Comparison of the treatment results between the groups

	Grup 1 (n=10 patients)	Grup 2 (n=9 patients)	P-value
Marginal bone loss (mm)	0.82±0.36 (0.46-1.65)	2.14±0.65 (1.45-3.16)	0.000*
Implant failure, n (%)	0 (0)	4 (11.1)	0.081
Prosthetic complication, n(%)	1 (10)	4 (44.4)	0.119
Implant success rate (%)	90	55	0.119

Note: Data are presented as mean±standard deviation (minimum-maximum)

* There were significant differences between the groups in marginal bone loss (P<0.05)

One patient in Group 1, where fixed prostheses were utilized, suffered a prosthetic complication in the form of a veneer-porcelain fracture. In Group 2, where removable prostheses were utilized, four patients developed prosthetic complications. Of these patients, three experienced the loss of attachment and abutment screw loosening while the other patient suffered an acrylic resin fracture. However, the two groups did not significantly differ with regard to prosthetic complications (P>0.05).

On one hand, our study revealed an implant success rate of 73.7%. Only one patient in Group 1 had prosthetic and biological complications. On the other hand, four patients in Group 2 developed prosthetic complications, two of whom also developed biological complications. The final implant success rate was 90% in Group 1 and 55.6% in Group 2, without a statistically significant difference (P>0.05).

Our study found a mean marginal bone loss of 1.45 mm. Bone loss was 0.82 mm in Group 1 and 2.14 mm in Group 2, with the difference being statistically significant (P<0.05) (Figure 2A,B) (Figure 3A,B). Furthermore, marginal bone loss was significantly greater among patients suffering prosthetic complications (P<0.05) (Table 2).

No correlation was found between the ages and marginal bone loss in Group 1 (P> 0.05; r=0.292) and Group 2 (P>0.05; r=0.333).

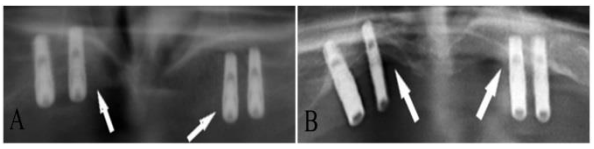

Figure 2. A. Post-operative radiographic image of a patient with removable prosthesis. **B.** Radiographic image of the patient during the follow-up period. Increased marginal bone loss around the implants (white arrow).

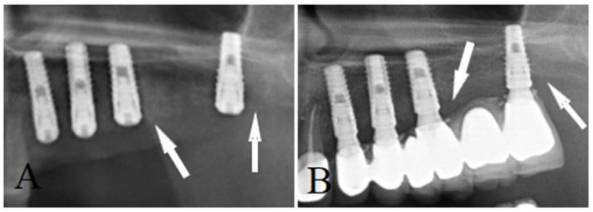

Figure 3. A. Post-operative radiographic image of a patient with fixed prosthesis. **B.** Radiographic image of the patient during the follow-up period. Minimal marginal bone loss around the implants (white arrow).

Discussion

The present study assessed the treatment success rate of implant therapy using two prosthetic restoration types among 19 patients who underwent simultaneous implant surgery with the split crest technique in the maxillary region. The study showed a greater marginal bone loss in patients who were rehabilitated with implant-supported overdentures than those who were rehabilitated with implant-supported fixed prostheses. However, the two groups achieved similar clinical outcomes with respect to prosthetic complications, implant failure, and implant success rate.

In atrophic jaws, particularly in the case of inadequacies in buccolingual direction, the volume of the jawbone should be augmented in order to perform implant therapy. Various techniques such as autogenous onlay bone grafts, guided bone regeneration, and alveolar distraction osteogenesis may be used for repair of the horizontally resorbed alveolar region. Disadvantages of the above mentioned techniques have led to the development of the split crest technique as an alternative (3, 4, 7). The split technique, a satisfactory procedure among crest expansion techniques, allows for horizontal expansion but no vertical expansion (17). As vertical bone volume augmentation was not needed, the split crest technique was preferred providing expansion in horizontal direction.

In the split crest technique many different materials can be utilized for the splitting; these materials include piezo surgery, sharp osteotomes, ultra-thin fissure drills, and a surgical scalpel (5, 6). The most significant risk of the split crest technique is the fracture of the labial cortex (1). Therefore, it requires careful surgery. To ensure the thin alveolar bone would not break at the split region, a mid-crestal starting osteotomy was performed with a scalpel with blade no 15 and the split procedure was completed using thin osteotomes as necessary.

The implant procedure can be carried out in a single stage simultaneously with the split crest technique or in two stages as a staged procedure in the maxilla (1, 5, 18). Although it is simple to provide primary implant stability and optimum implant positions with the two-stage technique, the treatment duration is prolonged and there is greater surgical trauma. However, with the single-stage procedure there is difficulty providing primary stability and optimal implant position, but it has the advantages of lesser trauma and a shortened total treatment duration (5). The implants were inserted simultaneously with the split crest technique owing to the decent upper jaw supply and the advantages provided by the single-stage procedure.

The split crest technique, including the implant surgery where osteotomized bone segments are formed, can reportedly utilize many materials such as autogenous, allogenous, heterogenous, and alloplastic graft materials alone or in combination (4, 19). Likewise, the current study used allograft materials and an autogenous graft combined to fill inter-segment spaces.

Former studies have utilized both periapical and panoramic radiograms to determine marginal bone loss (2, 5, 6, 20). As a single patient received multiple implants in our study, a digital panoramic radiography was used to assess the relationship of the implants with adjacent structures and teeth and to quantify marginal bone loss both during implant planning and follow-up periods.

The amount of marginal bone around dental implants plays an important role in implant therapy (21). Albanese et al.(22) reported a mean neck resorption of 1.19 mm during a one-year period after implant therapy using the split crest technique while Gherke et al.(5) reported a corresponding figure of 1.76 mm at the end of five months. Furthermore, Filho et al.(2) reported that bone loss amounted to 0.47 mm in six months and reached 1.93 mm in 10 years. However, a systematic review reported a marginal bone loss amounting to 0.8–1.9 mm among patients that underwent the split technique (19). In the current study, like previous studies, the mean amount of marginal bone loss was found to be 1.45 mm. However, that loss was 0.82 mm in Group 1 but 2.14 mm in Group 2. The amount of marginal bone loss was significantly greater in Group 2, which rehabilitated with removable prostheses (overdenture), than in Group 1, which rehabilitated with fixed prostheses (P<0.05). This may have been due to a greater rate of prosthetic complications in Group 2 compared to Group 1 in our

study, where patients with prosthetic complications also had a greater marginal bone loss.

Various studies have examined the implant survival rate to determine treatment success after the split crest technique. Those studies have reported implant survival rates of 94%–98% (2, 5, 22). Similarly, two systematic reviews have found an implant survival rate as high as 97% after the split crest technique (4, 23). In line with the literature, we found an implant survival rate of 95%. However, this rate was 88.8% and 100% for Group 2 and Group 1, respectively, with both groups being statistically similar with regard to implant failure (P>0.05).

Goodacre et al. (24) reported the complication rate associated with implant-supported overdenture prostheses was greater than implant-supported fixed prostheses. Nedir et al.(13) followed 236 patients for eight years and, similar to Goodacre et al. (24), found the complication rate was greater with implant-supported overdenture prostheses (60%) compared to implant-supported fixed prostheses (11%). Bilhan et al. (25), on the other hand, reported no significant difference between the complication rates of removable and fixed prostheses. Also in the current study, the complication rate with fixed prostheses (10%) was found to be smaller than that associated with removable prostheses (44.4%), but that difference did not reach statistical significance (P>0.05). This may due to the low number of patients in our study. At the same time, an increased prosthetic complication rate in the removable prosthesis group led to a lower implant success rate. Similarly, certain other studies have shown that the problems arising with implant-supported overdenture prostheses are mainly related to retainer clips, acrylic resin, or artificial tooth fracture whereas veneer-porcelain fracture and screw loosening occurred more commonly with implant-supported fixed prostheses (11, 15, 24, 26). Similar to the above mentioned studies, the current study revealed a greater amount of retention loss and abutment screw loosening with implant-supported overdenture prostheses, while one patient that received a fixed prosthesis experienced a veneer-porcelain fracture.

In the literature, although increasing age is accepted as one of the risk factors for success of dental implant treatment, the specific nature of the disease process, such as osteoporosis, decreased vascularity, mostly related to aging, are more decisive factor for the success (27, 28). In the present study, patients with systemic disorders that would be associated with higher risk of implant failure were not included. The results of this study revealed that the age factor did not cause significant correlations with marginal bone resorption for both groups (P>0.05).

In conclusion, the split crest technique may be used as an effective bone expansion procedure for implant installation in suitable cases with alveolar atrophy in the horizontal direction. On the other hand, the marginal bone loss around the implants was higher in the implant-supported removable prostheses than the fixed prostheses when implant insertion is performed with the split crest technique. However, both prosthetic restoration types yielded similar clinical outcomes with regard to implant survival rate, implant success, and prosthetic complications. Among patients receiving implant-supported removable prostheses, the amount of marginal bone loss may increase over time potentially leading to a greater rate of clinical failure. This study has limitations which potentially affect its findings, including a small sample size and a short follow-up period. Hence, studies with a larger sample size and longer follow-up time are needed to compare different prosthetic restoration types and surgical techniques.

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Conflict of Interest

We declare that we have no conflict of interest.

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