Effect of alveolar bone recontouring of mandibular atrophied ridge on clinical and radiographic outcomes of implants supporting All on 4 fixed restorations. A two- years clinical trial

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ABSTRACT

Purpose*: This study aimed to evaluate the influence of alveolar bone recontouring of mandibular atrophied ridge on outcomes of implants supporting All on 4 fixed restorations.* ***Materials and methods:*** *Six edentulous participants (study group) with inadequate buccolingual ridge width (knife edge ridge) received alveolar ridge recontouring (osteoplasty) before implant placement. Control group consisted of 6 patients with normal ridge width (with no need of osteoplasty) who were case matched to study group. Four implants were inserted in both groups according to the All on 4 protocol and the implants were immediately loaded with fixed acrylic prosthesis. After 3 months final prosthesis was delivered. Clinical (survival rate, pocket depth, and implant stability) and radiographic (crestal bone loss) outcomes were measured at baseline, 3 months, 6 months, 12 months and 24 months after implant insertion.* ***Results:*** *The survival rate was 97.9% and 100% in control and study groups respectively without significant difference between groups. For both groups, probing depths significantly increased from baseline to 6 months, then significantly decreased at 12 months. For control group, implant stability significantly decreased from baseline to 3 months, then significantly increased from 3 months to 6 months, then significantly increased later. In study group, implant stability did not differ between baseline, 3 months and 6 months, then increased significantly at 12 months. Crestal bone loss significantly increased from base line to 12 months. No significant difference in pocket depth, implant stability and bone loss were observed between 12 and 24 months. Study group had significant higher pocket depth and implant stability than control group, while control group had significant higher crestal bone loss than study group.* ***Conclusion:*** *Within the limitation of this study, alveolar bone recontouring (osteoplasty) of mandibular knife edge ridge before insertion of implants according to the All on 4 concept has improved clinical and radiographic outcomes compared to implant insertion without osteoplasty as it was associated with excellent implant survival rate, increased implant stability and reduced crestal bone loss. However, it was associated with increased pocket depth in the first 6 months.*

INTRODUCTION

Atrophied mandibular ridges is a common problem for rehabilitation of old age edentulous patient[1]. Patients with resorbed ridges usually have problems with their conventional dentures due to reduced load bearing capacity and lack of retention and stability of the dentures [2]. Such patients usually experience pain during chewing, impaired oral function and psychosocial problems[3, 4]. Osseointegrated implants supporting fixed prosthesis provide an excellent alternative for conventional dentures [5]. However, atrophic mandibular ridges presented a significant challenge to successful oral rehabilitation with dental implants[6]. Resorption of mandibular bone after extraction usually resulted in a residual ridge with adequate height but inadequate buccolingual width (very narrow, Class IV knife-edge alveolar ridge[7]). Pietrokoviski et al.[8] evaluated the morphology of the edentulous ridges and found that 43% of participants had a knife-edge alveolar crest in the mandible.

Adequate amount and dimensions of bone (bone height and width) could be present at implant site to ensure successful long term implant outcomes with at least 1mm of bone buccal and lingual to each implant[9]. Therefore, restoring the alveolar bone width in patients with knife edge ridge prior to implant placement is necessary[8]. Although ridge augmentation can help to restore ridge volume, grafting procedures can significantly increase patient morbidity, costs, and treatment time[10, 11]. Osteoplasty (recontouring of the ridge) is a surgical procedure in which the

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crest of the knife edge alveolar ridge is reduced or flattened to restore buccolingual ridge width required for implant installation[12]. Osteoplasty can eliminate sharp bone at the crest of the ridge without the need of extensive surgical procedures such as onlay bone grafts, guided bone regeneration, horizontal distraction and sagittal osteotomy[12, 13].

Loss of natural teeth and wearing conventional dentures for long period usually result in severe atrophy of the ridge with superficial mandibular alveolar nerve which constitutes unfavorable situation for implant installation using the conventional protocol as minimum bone volume is present posterior to the mental foramina [14]. Malo et al. [15, 16] developed the "All on 4 implant concept" for patients with atrophied ridges. This concept includes installation of 4 implants in the interforaminal region (2 axial implants in the lateral incisor or canine areas and 2 posterior inclined implants just anterior to the mandibular foramina) to support a fixed restoration. The protocol has several advantages such as; reduction of extensive surgical approaches such as bone augmentation or nerve displacements which may be unsuitable for elderly patients with compromised medical conditions, improving bone to implant contact by using longer posterior implants, reduction of cantilever length of the prosthesis [17, 18]. Moreover, immediate functional loading of the implants can be performed with the screw retained fixed provisional restoration which immediately restore function and aesthetics, and reduce cost and time[19]

In order to place implants according to the All on four concept, a vertical bone reduction may be needed to create an shelf of bone which is known as: All on 4 shelf[20]. Reviewing the literature, the effect of alveolar bone recontouring (osteoplasty) of knife edge ridges before implant placement compared to implant installation without bone recontouring on outcomes of implants supporting All on 4 fixed restorations in the edentulous mandible was not investigated in clinical studies. Only a three-dimensional finite element analysis study[12] studied the effect of crestal bone osteoplasty before implant placement on peri-implants stresses and concluded that recontouring of the knife edge ridges without exposure of cancellous bone can improve peri-implant bone stress distribution. Accordingly, the aim of this clinical trial was to compare clinical and radiographic outcomes of implants inserted in knife edge ridges recontoured with osteoplasty and normal ridges without bone recontouring to support All on 4 fixed restorations after 2 years. The null hypothesis is that there will be no significant difference in the tested outcomes between the two surgical techniques.

MATERIALS AND METHODS

Patient characteristics and study design

The trial was designed to be a prospective non-randomized case-control study. All included participants were an edentulous patients with atrophic mandibular ridges referred from the Prosthodontic department to the outpatient clinic of the oral and maxillofacial department for implant placement according to the All on Four protocol[15, 16] in the edentulous mandibles. Study group consisted of six edentulous participants (3 men and 3 women, mean age 56.6±4.6 years) who had inadequate buccolingual ridge width (knife edge ridge, Class IV according Cawood and Howell [7]) in the crestal region of the ridge as diagnosed in preoperative cone beam computerized tomography (CBCT, fig 1a). Control group (fig 1b) consisted of six edentulous participants with adequate buccolingual ridge (no need of osteoplasty) who were case-matched to the study group regarding age, gender, and years of edentulism. Included participants were required to have; 1) conventional maxillary and mandibular dentures constructed with balanced occlusion and worn at least 3 months is to enhance muscle adaptation, 2) at least one year elapsed from the last extraction, 3) adequate bone height to receive implants of at least 11mm in length, 4) Class II or III bone density according to Lekholm & Zarb [21] and 5) preference for implant supported fixed restoration with refusion of any type of bone augmentation procedure. Patients were excluded if they had one of the following conditions; 1) chemotherapy or radiotherapy to the head region, 2), medical conditions that affect the bone metabolism such as diabetes mellitus and hyperparathyroidism, 3) bleeding disorders, 4) immunosuppressive drugs, and 5) smoking habit. The patients informed about the protocol of the study, then reviewed a written consent and signed the informed consent. The study protocol was reviewed by the local ethical committee of the faculty of Dentistry which are approved the study.

No randomization of participants between groups were performed. Study group included six of participants with knife edge ridges for whom an osteoplasty (alveolar ridge recontouring) was performed before implant placement. Control group included six participants with normal width of residual ridge for whom implant placement was performed without bone recontouring. All participants received four implants in the interforaminal area of the mandible according to the All on four protocol and the implants were immediately loaded with fixed professional acrylic restoration. The final prosthesis was constructed after three months of implants placement. The preoperative cone beam CT was used to plan proper implant position and angulation according to All On 4 protocol and to detect the exact amount of bone needed to be removed during the osteoplasty to provide adequate ridge width. Also, the CBCT was used to detect the proper implant dimensions.

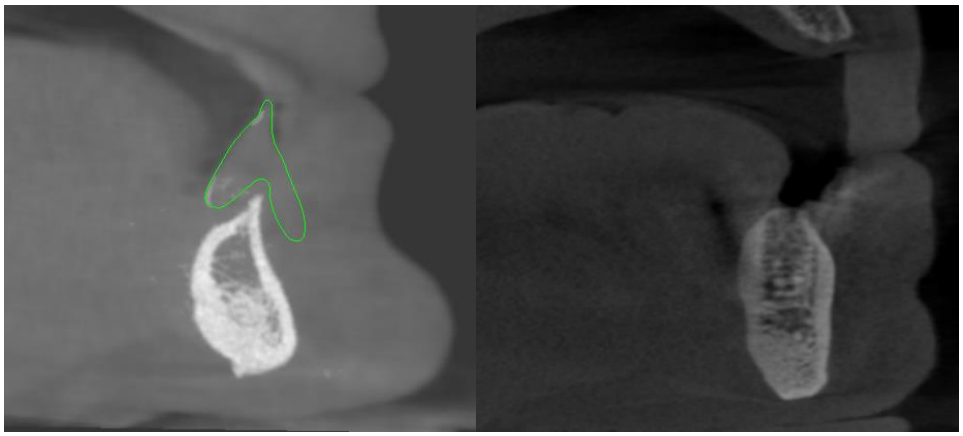

Fig 1. Preoperative CBCT; a, study group, b, control group

Surgical protocol

For both groups, surgery was performed under local anesthesia. Bilateral mandibular alveolar nerve block was performed using Articaine HCL 4% (ArtPharmaDent, 1:200,000 epinephrine). Preoperative sedation with diazepam (Valium 10 mg) was performed to all participants. Prophylactic antibiotic [(Augmentin® 1gm (amoxicillin 875 mg + clavulanic acid 125 mg)] was given the day before surgery (every 12 hours), then continued seven days postoperatively twice-daily. Chlorhexidine digluconate 0.2% mouth rinse started one day before surgery and continued for 7 days postoperatively. A crestal incision was made from premolar area on one side to premolar area on the other side and full-thickness mucoperiosteal flap was reflected buccally and lingually to reveal bone contour and concavities. Additionally, a midline vertical releasing incision was performed (fig 2).

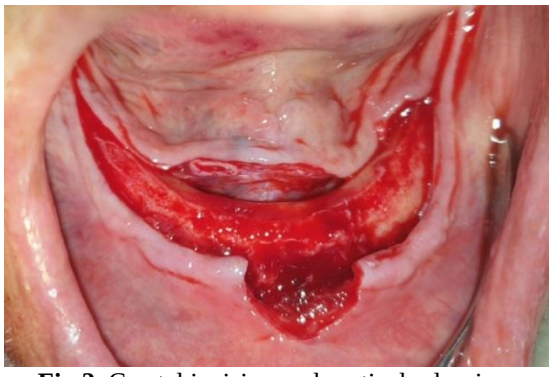

Fig 2. Crestal incision and vertical releasing incision (control group)

The mental foramina and the mental nerve loop were identified with a dramatic instrument[14]. For study group, osteoplasty and bone recontouring was performed for knife edge ridges using rotatory instruments (crestal osteotome, Dentium) with motor speed of 1200 RPM under copious irrigation with saline to avoid bone

overheating. Bone recontouring was performed to remove the sharp edge of the bone at the crestal region along the entire ridge length and to flatten the ridge. Bone file was used to remove sharp edges of bone at buccal and lingual aspects of the ridge. The amount of bone recontouring was governed by the initial ridge width as osteoplasty was continued until at least 1mm of cortical bone is present buccally and lingually to each implant (fig 3).

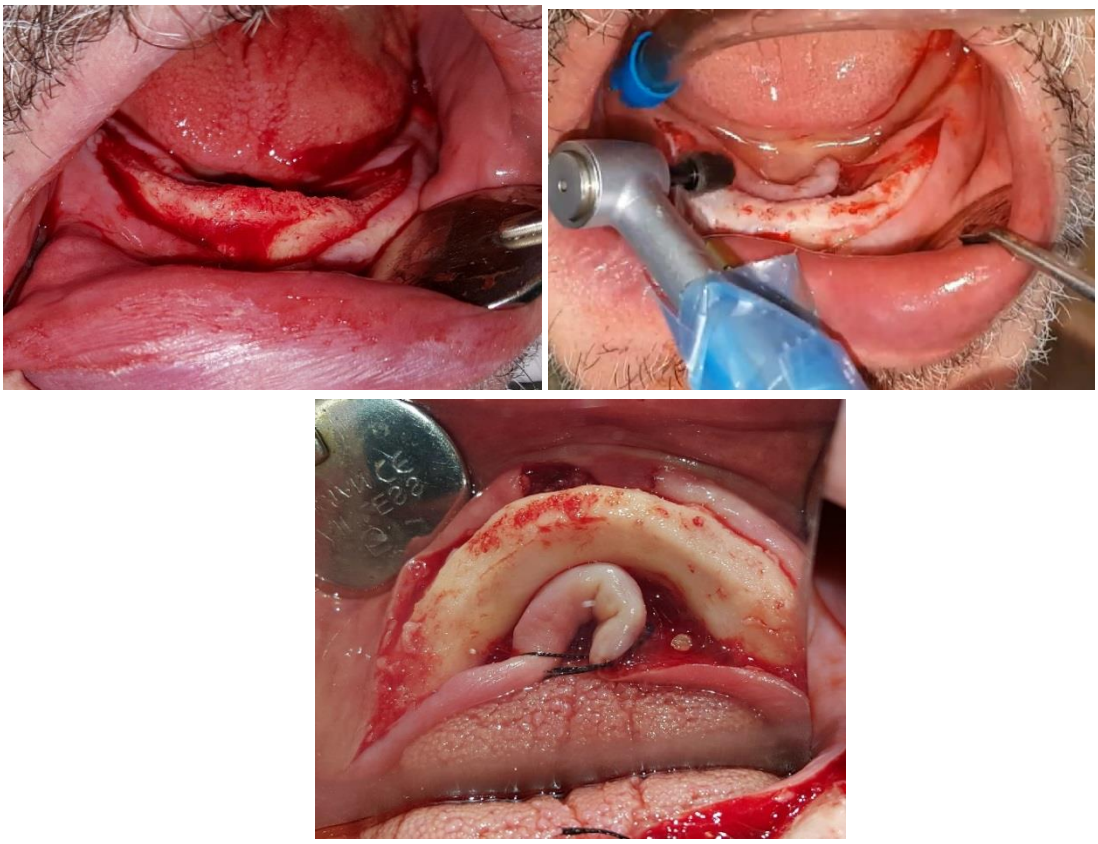

Fig 3. Knife edge ridge (study group, a, crestal incision and midline releasing incision, b, bone recontouring (osteoplasty) using crestal osteotome under copious irrigation, c, ridge width after osteoplasty

For control group, no ridge recontouring was performed and the implant platform was positioned at the level of the ridge crest. For both groups at midline Osteotomy was performed using a pilot to allow fixation of central pin of the u-shape metal guide (Malo metal guide designed for implant placement, JDental care). The guide has vertical lines parallel to each other to guide placement of anterior vertical implants. In addition, and inclined line connecting the top of the vertical line at premolar area of the bottom of vertical line at lateral incisor area formed the direction of 30^{o} of distal inclined implants at premolar areas. The guide was fixed to the mandibular bone at midline and bended to follow the contour of the ridge (fig 4a) . Implant osteotomes was performed using successive drills of increasing diameters. Four implants (Tiologic, Germany, 3.6 to 4mm in diameter and 11-13mm in length) were inserted in the interforaminal area. The posterior implants were distally inclined 30^{o} from the vertical plane and the position just anterior to the mental foramina with safety margin from the foramina and the mental nerve according to the "All on four protocol"[15, 16] (fig 4a). The posterior implants emerged in the second premolar regions. The anterior implants were inserted parallel to each other and perpendicular

to the occlusal plane in the lateral incisor area. This implant configurations provide several merits such as excellent implant support, short cantilever length, and large interimplant distance[14, 17, 18]. The platforms of the anterior implants were leveled to the crest of the ridge, while for posterior inclined implants, the platform was submerged in the bone so that the mesial portion of the platform was leveled at the crest of the ridge and the distal portion was submerged in the bone. In case of increased bone density countersinking was performed. Conversely, in case of reduced bone density, the last drill was omitted (under preparation of the osteotomy) to obtain adequate primary stability required for immediate loading (at least 35 Ncm). Straight multiunit abutments were connected to the anterior implants and angled multiunit abutments were threaded to the posterior implants to correct implant angulation (fig 4b). For study group, the flap was trimmed to avoid excess soft tissue. The flap was closed around the abutments with interrupted sutures (Vicryl, 0000) (fig 4b).

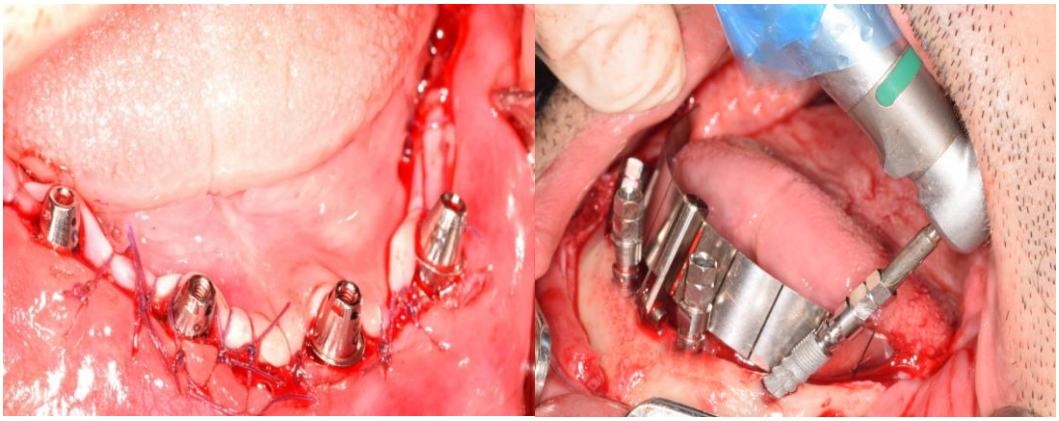

Fig 4. Implant insertion and abutment connection: a; implant installation using Malo metal template as a guide for proper position and angulation of the implants, b; multiunit abutment connection and flap closure around the abutments

Prosthetic protocol and the postoperative care

Titanium metal caps were connected to the multiunit abutments. Rubber dam sheets were snapped over the titanium caps and the implants were immediately loaded with provisional acrylic restoration. The existing mandibular dentures was converted to fixed acrylic professional restoration by removing the denture flanges and hollowing the denture above titanium caps. The dentures were picked up to the caps using self-cure acrylic resin while the patients holding the dentures in centric occlusion. The second molar artificial teeth were removed, and the occlusion was performed at the area of first molars and second premolars to present overloading for inclined implants. Occlusal contact was limited to the anterior teeth only. Patients were instructed to eat soft diet apply ice packs after surgery and performing adequate oral hygiene. Regular recall visits were scheduled for all participants for making the necessary adjustments and evaluation of oral hygiene practice. Postoperative medications included antibiotics and mouthwash as previously described. In addition, corticosteroid drugs (Dexamethasone) were prescribed for 4 days after surgery. Anti-inflammatory medications (Alphintern) and analgesics (Ketolac 10mg) were prescribed 3 times daily for 7 days post surgically. Three months later, Open tray impression was made on the abutment level, and fixed porcelain fused to metal screw retained hybrid restoration that store the lost teeth and alveolar bone with pink porcelain was constructed (fig 5). The prosthesis included 12 artificial teeth (from first molar area on one side to first molar area on the other side). Panoramic x-ray was made to ensure complete seating and passive fit of the prosthesis (fig 6). Regular recall visits were scheduled for all participants for evaluation of peri-implant clinical and radiographic outcomes.

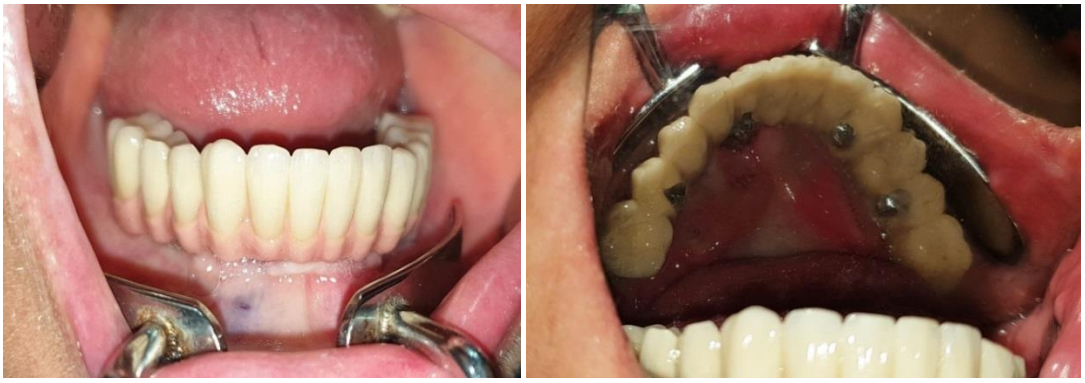

Fig 5. Fixed porcelain fused to metal screw retained hybrid restoration; a, buccal view, b; occlusal view

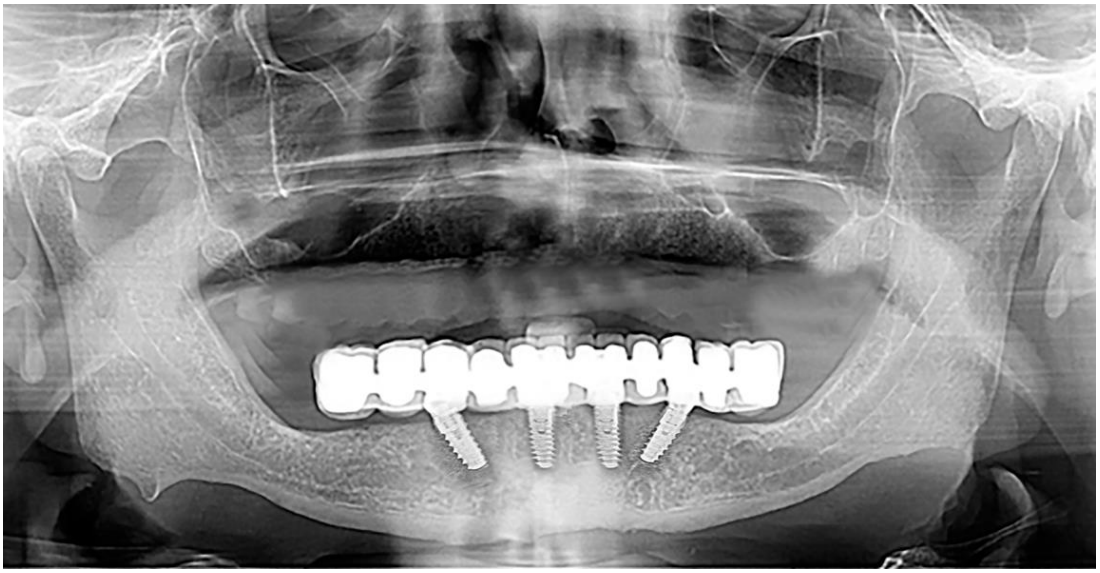

Fig 6. Panoramic radiograph with final prosthesis in place

Measurement of clinical and radiographic outcomes

Clinical outcomes included implant survival rate, pocket depth, and implant stability, while radiographic outcomes included crestal bone loss.

Albrektsson et al[22] which include absence of pain or dysesthesia, absence of addiction, no mobility of the implant, crestal bone loss <1.5mm in the first 12 months. The survival rate of the implant was defined as implant remains in situ but did not meet the described success criteria. Peri-implant pocket depth was measured (PD, in mm) by graduated plastic periodontal probe which inserted in peri-implant gingival Sulcus to measure the distance between free gingival margin and the most apical probing depth[23]. Measurement was performed at mesial, distal, buccal and lingual surface of each implant, then the mean was used for each implant. The mean measurements of the four implants were used in the statistical analysis. Resonance frequency analysis using Osstell device (Integration Diagnostics) was used to measure implant stability as implant stability quotient (ISQ). The SmartPeg specific for the implants -type was screwed to the multiunit abutments and the hand of the device was then held perpendicularly to the long axis of SmartPeg and the measurements were

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made in the buccolingual and mesiodistal direction. Three measurements were performed and the mean was used for each implant, then the mean measurements for all implants was used in the statistical analysis.

Crestal bone loss (CBL) was measured using digital periapical radiographs taken with long cone paralleling technique and a customized film positioner. Custom acrylic jig for each implant was used to hold the film between the occlusal surface of maxillary and mandibular teeth to maintain a repeatable position of the film during subsequent exposures and to maintain the same film-implant and cone -implant distance for standardization. A digital radiographic device (Digora, Soredex) with accompanying software was used to acquire digital periapical radiographs and the measured peri-implant crestal bone loss. The linear distance between implant-abutment junction, and implant-bone contact was measured (in mm) to represent crestal bone height. To calculate crestal bone loss, crestal bone height at the follow-up visits (3 months, 6 months, one year and 2 years) were subtracted [24-27]Clinical and radiographic outcomes were measured by two blind examiners immediately after implant insertion, 3 months, 6 months, one year and 2 years after implant insertion

Statistical analysis

The SPSS software version 22 was used for data analysis. Shapiro Wilk Test of normality was used to determine normal distribution of collected data. α (Cronbach) test was used to test the inter-examiner agreement. Comparison of clinical and radiographical outcomes between time intervals (implant insertion/base line, 3 months, 6 months, one year and 2 years after implant insertion) and between groups was performed using Repeated measures Analysis of Variance (Repeated ANOVA). If significant differences were detected, Bonferroni post hoc test was used for pair-wise comparisons. Kaplan-Meier analysis was used to calculate implant survival rate and the log rank test was used to compare survival rates between groups. P value <.05 was considered significant at 95% confidence interval.

RESULTS

Kaplan-Meier analysis was used to test the survival functions of both groups over the years (fig 7). Two inclined implants in one patient failed in the control group within the first three months after implant placement. However, no implant failures occurred in the study group. Therefore, the survival rate was 97.9% and 100% in control and study groups respectively. There was no significant difference in survival rates between control and study groups (log rank test, p=1.66). The failed implants were associated with mobility, peri-implant deep pockets with suppuration. The implants were removed, and the patient was scheduled for bone grafting procedures and was excluded from the study. Intention to treat principal was followed. Consequently, the rest of the patients were included in the analysis. Interexaminer agreement was calculated using α- Cronbach test to determine agreement between observers and the collected data (pocket depth, implant stability, and crestal bone loss) showed a good agreement between observers (correlation Coefficient was >.80). Consequently, the data were considered reliable.

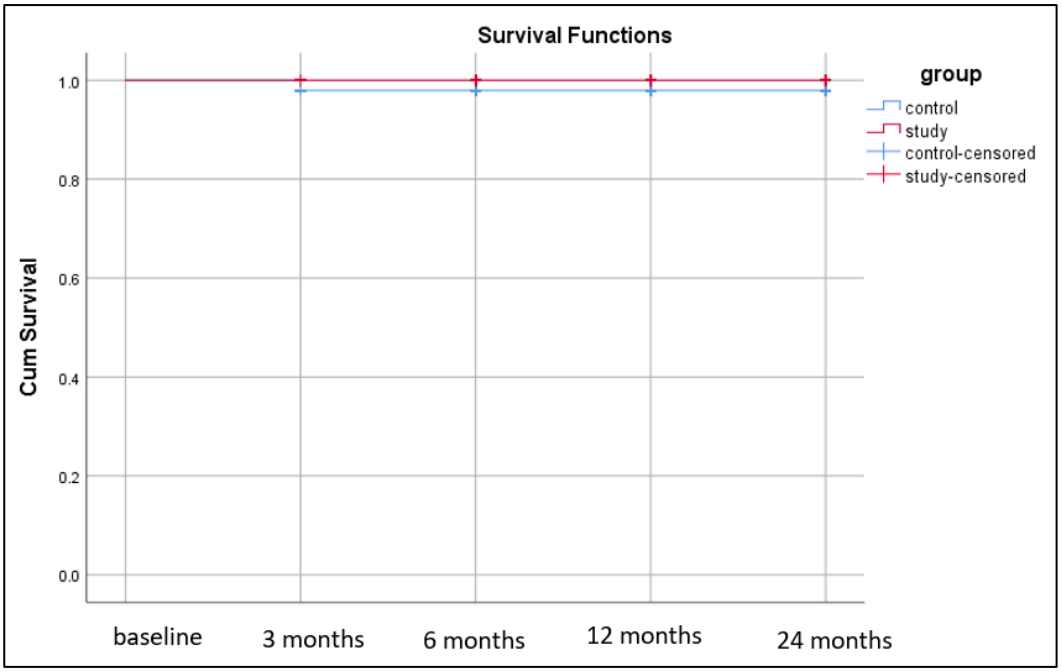

Fig. 7: Kaplan-Meier survival analysis for both groups

Comparison of peri-implant pocket depth between control and study groups and between different time intervals is presented in table 1. There was a significant difference in pocket depth between time intervals for control (p=.004) and study (p=.001) groups. For both groups, probing depths significantly increased from baseline to 3 months, then significantly increased from 3 months to 6 months, then significantly decreased at 12 months and 24 months. There was no significant difference in probing depth between 12 months and 24 months. At baseline, 3 months, and 6 months, study group had significant higher pocket depth than control group. At 12 months and 24 months, no significant difference in pocket depth between groups was noted.

Table 1: Comparison of peri-implant pocket depth between control and study groups and between different time intervals

	Control group (Without osteoplasty) X±SD	**Study group (With osteoplasty) X±SD**	**Repeated measures ANOVA (p value)**
Base line (at time of surgery)	1.00±.25 a	1.4±.28 a	.002*
3 months after implant placement	1.6±.31 b	1.9±.35 b	.003*
6 months after implant placement	1.9±.40 c	2.2±.34 c	.037*
12 months after implant placement	1.7±.29 d	1.8±.28 d	.158
24 months after implant placement	1.6±.37 d	1.5±.33 d	.135
Repeated measures ANOVA (p value)	.004*	.001*	

X; mean, SD, standard deviation, the same letters in the same column indicate no significant difference between each two-time intervals (Bonferroni test, p>.05), while different letters in the same column indicate significant difference between each two-time intervals (Bonferroni test, p<.05). *P is significant at 5%

Comparison of implant stability between control and study groups and between different time intervals is presented in table 2. There was a significant difference in implant stability between time intervals for control (p=.001) and study (p=.021) groups. For control group, implant stability significantly decreased from baseline to 3 months, then significantly increased from 3 months to 6 months, then significantly increased from 6 months to 12 months. There was no significant difference in implant stability between 12 months and 24 months. For study group, there was no significant difference in implant stability between baseline, 3 months, and 6 months. Implant stability increased significantly from 6 months to 12 months. There was no difference in implant stability between 12 months and 24 months. At all time intervals, study group had significant higher implant stability than control group.

Table 2: Comparison of implant stability between control and study groups and between different time intervals

	Control group (Without osteoplasty) X±SD	**Study group (With osteoplasty) X±SD**	**Repeated measures ANOVA (p value)**
Base line (at time of surgery)	63.95±2.5 a	65.84±2.7 a	.032*
3 months after implant placement	61.55±3.1 b	65.13±2.9a	.001*
6 months after implant placement	63.15±3.2 c	65±3.3 a	.027*
12 months after implant placement	64.12±2.9 d	66.62±3.6 b	.024*
24 months after implant placement	64.22±3.4 d	66.75±3.8 b	.028*
Repeated measures ANOVA (p value)	.001*	.021*	

X; mean, SD, standard deviation, the same letters in the same column indicate no significant difference between each two-time intervals (Bonferroni test, p>.05), while different letters in the same column indicate significant difference between each two-time intervals (Bonferroni test, p<.05). *P is significant at 5%

Comparison of crestal bone loss between control and study groups and between different time intervals is presented in table 3. There was a significant difference in crestal bone loss between time intervals for control (p=.009) and study (p=.011) groups. For both groups crestal bone loss significantly increased significantly from 3 months to 6 months , then significantly increased from 6 months to 12 months. There was no significant difference in crestal bone loss between 12 months and 24 months. At all time intervals, control group had significant higher crestal bone loss than study group.

Table 3: Comparison of crestal bone loss between control and study groups and between different time intervals

	Control group (Without osteoplasty) X±SD	Study group (With osteoplasty) X±SD	Repeated measures ANOVA (p value)
Base line (at time of surgery)	-	-	.032*
3 months after implant placement	.79±.28a	.51±.15a	.003*
6 months after implant placement	.95±.18b	.74±.24b	.001*
12 months after implant placement	1.2±.29 c	.91±.26 c	.004*
24 months after implant placement	1.3±.24 c	1.0±.20 c	.008*
Repeated measures ANOVA (p value)	.009*	.011*	

X; mean, SD, standard deviation, the same letters in the same column indicate no significant difference between each two-time intervals (Bonferroni test, p>.05), while different letters in the same column indicate significant difference between each two-time intervals (Bonferroni test, p<.05). *P is significant at 5%

DISCUSSION

The survival rate was 97.9% and 100% in control and study groups respectively. Similarly, the survival rate of implants supporting All on four fixed prosthesis in the mandible were reported to range between 93.2% and 100% after 1 to 5 years.[28] The increased survival rate in both groups may be attributed to the good bone quality and density in the interforaminal area of the mandible which increase implant stability required to resist of micromotions caused by immediate loading of the implants. Also, the splinting of the implants with fixed professional restoration stabilizes the implants against unfavorable mechanical loading[29]. The 2 failed implants in the control group occurred in the first three months after implant placement and may be attributed to overloading of the inclined posterior implants (caused by immediate loading by fixed acrylic prosthesis) in the critical healing period which may disrupt osteointegration[30]. However, these failures caused no significant difference in the survival rate between groups.

Alveolar bone reduction (osteoplasty) or recontouring of the ridge before All on 4 implant placement in the mandible to provide what is called "All on 4 shelf" may be recommended especially in patients with sharp or knife edge ridges as it provide several advantages such as; reduction of nerve injury by proper identification of nerve position, proper definition of jaw anatomy, accurate implant placement and angulation, reduction of the need of bone augmentation procedure, establishment of a uniform level of alveolar plane and implant platforms, restoration of alveolar bone with of knife edge ridges that allow placement of standard diameter implants [20]. From the results of this study, alveolar bone recontouring (osteoplasty) of mandibular knife edge ridge before insertion of implants according to the All on 4 concept has improved clinical and radiographic outcomes. In agreement with this observation, Beretta et al.[31] in a clinical report, demonstrated that implant insertion using a computer guided surgery after alveolar ridge reduction had a stable clinical and radiographic outcomes after one year. Similarly, Jensen et al. [20] reported that osteoplasty and flattening the alveolar bone before implant placement did not lead to a greater incidence of implant loss or higher complications.

For both groups, probing depths significantly increased from baseline to 6 months, then significantly decreased at 12 months. The increased pocket depth could be attributed to peri-implant mucosal enlargement and inflammation caused by suturing the flap over to the multiunit abutments together with increased crestal bone loss [32]. The decreased pocket depth after 6 months may be attributed to the gingival healing and absence of gingival inflammation around the implants and to the mucosal recession caused by cleaning. The decreased pocket depth after one year was in line with another study[33] in which the authors reported a reduction of pocket depths for All on four implants supporting mandibular fixed prosthesis. Study group had significant higher pocket depth than control group within the first 6 months. This may be due to bone removal caused an access soft tissue which is trimmed to be properly readapted to the

abutments. This trimming may not be sufficient and may result in excess soft tissue around the abutments which when sutured to the abutments may result in gingival enlargement and increased pocket depth. However, the difference between groups disappeared after 6 months when complete gingival healing occurred.

For control group, implant stability significantly decreased from baseline to 3 months, then significantly increased from 3 months to 6 months and later. The reduced stability of implants after 3 months of may be due to increased implant micromotions caused by immediate loading which result in reduced bone to implant contact and bone remodeling [34] as the implants are inserted in predominantly alveolar bone. However, after osteointegration, the increased bone to implant contact along the implants surface as a result of healing and reorganization of bone may be responsible for increasing implant stability again. In study group, implant stability did not decrease and did not differ between baseline, 3 months and 6 months, also it increased significantly at 12 months. Moreover, study group had significant higher implant stability than control group. This may be due to bone recontouring usually result in thin buccal plate, narrow bone marrow trabecular space, and a thick lingual plate[20]. Therefore, the surgeon usually uses the thick lingual plate for implant fixation which often plays a key role to increases the primary stability of the implants because cortical anchorage usually results. Moreover, after osteoplasty, the implants are inserted mainly in the basal bone which is denser, therefore, the percentage of bone to implant contact increases and the implant stability increases compared to the implants in the control group which are placed in alveolar bone.

Crestal bone loss significantly increased from base line to 12 months. The increased crestal bone resorption with time in both groups could be attributed to the wound healing, reorganization of bone, and bone reaction to increased occlusal load[35]. However, as with results of other studies the majority bone loss on the first year after loading and no significant bone loss after 12 months occurred. Similarly, van Steenberghe [36] reported that bone loss tended to reach a plateau of one year. In this study the amount of bone resorption in both groups not exceeds 1.2mm first year. A similar amount of bone loss (1.13 mm) was reported for All on 4 implants inserted in the mandible after one year[37]. This amount is located within the normal range of values for bone resorption reported in the literature[22].

From the results of this study, it is interesting to find that study group was associated with significant lower crestal bone loss compared to control group. The reduced bone loss in the study group may be due to recontouring of the ridge removes a part of the alveolar bone and makes the baseal bone accessible for implant fixation. Therefore, the implants are inserted mainly in the basal bone which is more dense and have good bone quality than alveolar bone. The basal bone increased implant stability (as confirmed by the results of implant stability in this study) and helped to increase bone to implant contact, consequently bone loss decreased. It has been reported that basal bone has a reduced affinity to resorp than cancellous bone[38]. In contrast, the presence of large amount of cancellous bone in the control group together with immediate loading protocol may be resposibel for increased crestal bone loss in this group. Moreover, bone regeneration may occur after bone removal which may increase bone to implant contact[20]. In agreement with this observation, Jensen et al. reported that the flattening of the alveolar ridge before placement of All on four implants appeared to have no effect on bone loss around implants [20]. The reduced bone loss in the study group is in line with the finding of another biomechanical study[12] in which the authors reported that crestal bone osteoplasty before implant insertion and in knife-edge ridges helped to redistribute peri-implant crestal stresses over a larger area, thus reducing the maximum stress in the mesial and distal crestal peri-implant regions. Consequently, the reduction of peri-implant stresses caused a reduction of peri-implant the crestal bone loss and implant failures[39]. The authors added that sever reduction of alveolar crest (flattening) and exposure of cancellous bone resulted in increased stress concentration around the implants and may result in increased bone loss that may affect the long term success of the implants. This contrasts the results of the present study which showed reduction of crestal bone loss after osteoplasty regardless the amount of bone removed. In the current study, the amount of bone removal was not standardized but it was

depending on the anatomy of the knife edge ridge. Bone was removed until sufficient ridge width resulted which permit placement of implants with at least 1mm of bone present in the buccal and lingual aspect of each implant. The difference in the results between the 2 studies may be due to biomechanical studies did not necessarily represent the complex nature of the living tissues. Moreover, excessive micromotions that exceed 4000 microstrains that exceed the physiologic adaptive capacity of bone are needed to cause a crestal bone loss around the implants[40]. This excessive micromotions did not occurred since the implants were immediately splinted with the acrylic restoration as stated previously.

The limitations of this study included; the small sample size, lack of randomization between groups, and the lack of standardization of the amount of bone removal in the study group.

CONCLUSION

Within the limitation of this study, alveolar bone recontouring (osteoplasty) of mandibular knife edge ridge before insertion of implants according to the All on 4 concept has improved clinical and radiographic outcomes compared to implant insertion without osteoplasty as it was associated with excellent implant survival rate, increased implant stability and reduced crestal bone loss. However, it was associated with increased pocket depth in the first 6 months.

REFERENCES

1. Carlsson GE, Omar R. The future of complete dentures in oral rehabilitation. A critical review. J Oral Rehabil. 2010;37:143-56.
2. Al-Ghafli SA, Michalakis KX, Hirayama H, Kang K. The in vitro effect of different implant angulations and cyclic dislodgement on the retentive properties of an overdenture attachment system. J Prosthet Dent. 2009;102:140-7.
3. Heckmann SM, Heussinger S, Linke JJ, Graef F, Proschel P. Improvement and long-term stability of neuromuscular adaptation in implant-supported overdentures. Clin Oral Implants Res. 2009;20:1200-5.
4. Muller F, Hernandez M, Grutter L, Aracil-Kessler L, Weingart D, Schimmel M. Masseter muscle thickness, chewing efficiency and bite force in edentulous patients with fixed and removable implant-supported prostheses: a cross-sectional multicenter study. Clin Oral Implants Res. 2012;23:144-50.
5. Davis DM, Packer ME. Mandibular overdentures stabilized by Astra Tech implants with either ball attachments or magnets: 5-year results. Int J Prosthodont. 1999;12:222-9.
6. Santagata M, Guariniello L, D'Andrea A, Tartaro G. A modified crestal ridge expansion technique for immediate placement of implants: a report of three cases. J Oral Implantol. 2008;34:319-24.
7. Cawood JI, Howell RA. A classification of the edentulous jaws. Int J Oral Maxillofac Surg. 1988;17:232-6.
8. Pietrokovski J, Starinsky R, Arensburg B, Kaffe I. Morphologic characteristics of bony edentulous jaws. J Prosthodont. 2007;16:141-7.
9. Lekholm U, Adell R, Lindhe J, Branemark PI, Eriksson B, Rockler B et al. Marginal tissue reactions at osseointegrated titanium fixtures. (II) A cross-sectional retrospective study. Int J Oral Maxillofac Surg. 1986;15:53-61.
10. Stellingsma C, Vissink A, Meijer HJ, Kuiper C, Raghoebar GM. Implantology and the severely resorbed edentulous mandible. Crit Rev Oral Biol Med. 2004;15:240-8.
11. Stellingsma K, Raghoebar GM, Meijer HJ, Stegenga B. The extremely resorbed mandible: a comparative prospective study of 2-year results with 3 treatment strategies. Int J Oral Maxillofac Implants. 2004;19:563-77.
12. Hudieb M, Kasugai S. Biomechanical effect of crestal bone osteoplasty before implant placement: a three-dimensional finite element analysis. Int J Oral Maxillofac Surg. 2011;40:200-6.
13. Chiapasco M, Romeo E, Vogel G. Tridimensional reconstruction of knife-edge edentulous maxillae by sinus elevation, onlay grafts, and sagittal osteotomy of the anterior maxilla: preliminary surgical and prosthetic results. Int J Oral Maxillofac Implants. 1998;13:394-9.
14. Weinstein R, Agliardi E, Fabbro MD, Romeo D, Francetti L. Immediate rehabilitation of

the extremely atrophic mandible with fixed full-prosthesis supported by four implants. Clin Implant Dent Relat Res. 2012;14:434-41.
15. Malo P, Rangert B, Nobre M. "All-on-Four" immediate-function concept with Branemark System implants for completely edentulous mandibles: a retrospective clinical study. Clin Implant Dent Relat Res. 2003;5 Suppl 1:2-9.
16. Malo P, Rangert B, Nobre M. All-on-4 immediate-function concept with Branemark System implants for completely edentulous maxillae: a 1-year retrospective clinical study. Clin Implant Dent Relat Res. 2005;7 Suppl 1:S88-94.
17. Pozzi A, Sannino G, Barlattani A. Minimally invasive treatment of the atrophic posterior maxilla: a proof-of-concept prospective study with a follow-up of between 36 and 54 months. J Prosthet Dent. 2012;108:286-97.
18. Francetti L, Agliardi E, Testori T, Romeo D, Taschieri S, Del Fabbro M. Immediate rehabilitation of the mandible with fixed full prosthesis supported by axial and tilted implants: interim results of a single cohort prospective study. Clin Implant Dent Relat Res. 2008;10:255-63.
19. Sannino G, Bollero P, Barlattani A, Gherlone E. A Retrospective 2-Year Clinical Study of Immediate Prosthetic Rehabilitation of Edentulous Jaws with Four Implants and Prefabricated Bars. J Prosthodont. 2017;26:387-94.
20. Jensen OT, Adams MW, Cottam JR, Parel SM, Phillips WR, 3rd. The all on 4 shelf: mandible. J Oral Maxillofac Surg. 2011;69:175-81.
21. Lekholm U, Zarb G. Patient selection and preparation. In: Branemark PI, Zarb G, Albrektsson T, eds. Tissue integrated prosthesis: osseointegration in clinical dentistry. Chicago. Quintessence Publishing Co Inc. 1985:199-209.
22. Albrektsson T, Zarb G, Worthington P, Eriksson AR. The long-term efficacy of currently used dental implants: a review and proposed criteria of success. Int J Oral Maxillofac Implants. 1986;1:11-25.
23. ELsyad MA, Alameldeen HE, Elsaih EA. Four-implant-supported fixed prosthesis and milled bar overdentures for rehabilitation of the edentulous mandible: A 1-year randomized controlled clinical and radiographic study. Int J Oral Maxillofac Implants. 2019;34:1493–503.
24. Elsyad MA, Elsaih EA, Khairallah AS. Marginal bone resorption around immediate and delayed loaded implants supporting a locator-retained mandibular overdenture. A 1-year randomised controlled trial. J Oral Rehabil. 2014;41:608-18.
25. Elsyad MA, Mahanna FF, Elshahat MA, Elshoukouki AH. Locators versus magnetic attachment effect on peri-implant tissue health of immediate loaded two implants retaining a mandibular overdenture: a 1-year randomised trial. J Oral Rehabil. 2016;43:297-305.
26. Elsyad MA, Al-Mahdy YF, Fouad MM. Marginal bone loss adjacent to conventional and immediate loaded two implants supporting a ball-retained mandibular overdenture: a 3-year randomized clinical trial. Clin Oral Implants Res. 2012;23:496-503.
27. Elsyad MA, Khirallah AS. Circumferential bone loss around splinted and nonsplinted immediately loaded implants retaining mandibular overdentures: A randomized controlled clinical trial using cone beam computed tomography. J Prosthet Dent. 2016;116 741-8
28. Malo P, de Araujo Nobre M, Lopes A. The use of computer-guided flapless implant surgery and four implants placed in immediate function to support a fixed denture: preliminary results after a mean follow-up period of thirteen months. J Prosthet Dent. 2007;97:S26-34.
29. Laverick S, Summerwill A, Cawood JI. Ten years of experience with the anterior maxillary and mandibular osteoplasty (class IV ridges): a retrospective analysis of implant survival rates. Int J Oral Maxillofac Surg. 2008;37:415-8.
30. Ostman PO, Wennerberg A, Ekestubbe A, Albrektsson T. Immediate Occlusal Loading of NanoTite Tapered Implants: A Prospective 1-Year Clinical and Radiographic Study. Clin Implant Dent Relat Res. 2012.
31. Beretta M, Poli PP, Tansella S, Maiorana C. Virtually guided alveolar ridge reduction combined with computer-aided implant placement for a bimaxillary implant-

supported rehabilitation: A clinical report. J Prosthet Dent. 2018;120:168-72.
32. ELsyad MA, Denewar BA, Elsaih EA. Clinical and Radiographic Evaluation of Bar, Telescopic, and Locator Attachments for Implant-Stabilized Overdentures in Patients with Mandibular Atrophied Ridges: A Randomized Controlled Clinical Trial. The International journal of oral & maxillofacial implants. 2018;33:1103-11.
33. Landázuri-Del Barrio RA, Cosyn J, De Paula WN, De Bruyn H, Marcantonio E. A prospective study on implants installed with flapless-guided surgery using the all-on-four concept in the mandible. Clin Oral Implants Res. 2013;24:428-33.
34. Pae A, Kim JW, Kwon KR. Immediate loading of two implants supporting a magnet attachment-retained overdenture: one-year clinical study. Implant Dent. 2010;19:428-36.
35. Hekimoglu C, Anil N, Cehreli MC. Analysis of strain around endosseous dental implants opposing natural teeth or implants. J Prosthet Dent. 2004;92:441-6.
36. van Steenberghe D, Lekholm U, Bolender C, Folmer T, Henry P, Herrmann I et al. Applicability of osseointegrated oral implants in the rehabilitation of partial edentulism: a prospective multicenter study on 558 fixtures. Int J Oral Maxillofac Implants. 1990;5:272-81.
37. Browaeys H, Dierens M, Ruyffelaert C, Matthijs C, De Bruyn H, Vandeweghe S. Ongoing Crestal Bone Loss around Implants Subjected to Computer-Guided Flapless Surgery and Immediate Loading Using the All-on-4(R) Concept. Clin Implant Dent Relat Res. 2015;17:831-43.
38. Wright PS, Watson RM. Effect of prefabricated bar design with implant-stabilized prostheses on ridge resorption: a clinical report. Int J Oral Maxillofac Implants. 1998;13:77-81.
39. Duyck J, Ronold HJ, Van Oosterwyck H, Naert I, Vander Sloten J, Ellingsen JE. The influence of static and dynamic loading on marginal bone reactions around osseointegrated implants: an animal experimental study. Clin Oral Implants Res. 2001;12:207-18.
40. Frost HM. A brief review for orthopedic surgeons: fatigue damage (microdamage) in bone (its determinants and clinical implications). J Orthop Sci. 1998;3:272-81.