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Evaluation of related factors affecting stability and survival rate of dental implants (meta-analysis of retrospective study)

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Abstract

Aims: evaluate survival rate of dental implants. Determine correlations between bone density and stability. Determine which intervention to dental implant that increase stability.

Materials and methods: Retrospective study of patients receiving implants in dental implant unit in educational hospital of collage of dentistry /Baghdad University during period October 2012- October 2015. Individual data meta-analysis of implants stability using different interventions, which Are bone morphogenetic proteins, immediate dental implant, Ridge splitting, simvastatin drug, Platelet-Rich Plasma, Piezosurgery and control group.

Results: survival rate was 98.33%. Implant length and posterior location statistically significant effect on achieving high stability in control group. Posterior location statistically significant increase primary stability. After 2 months of surgery comparing interventions and control group show simvastatin($P<0.001$) increase stability and among variables diameter, length and mandibular location statistically significant increase stability. After 3 month simvastatin($P<0.001$) and Bone morphogenetic proteins($P=0.005$) increase stability and mandibular location, length and diameter increase stability. After 4 months Piezosurgery statistically significant lowering stability ($P=0.004$), and diameter statistically significant increase stability.

Conclusions: High survival rate achieved. No significant effect of variables on failure rate of implants. Simvastatin and Bone morphogenetic proteins reduce healing time and improve stability but Piezosurgery lowering stability compered to control. Posterior location affected primary stability but length and diameter increase secondary stability. Bone density had no effect on primary and secondary stability.

Key wards: dental implant, stability, meta-analysis, survival rate.

Introduction

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The usage of dental implants to restore lost teeth has become progressively widespread over the last decades. Several clinical studies with dental implants have discovered promising outcomes. The successful result of any implant procedure necessitates a series of patient related and procedure dependent factors [1]. Implant stability plays a vital role for successful osseointegration which has been viewed as a direct structural and functional connection existing between bone and the surface of dental implant [2,3]. Achievement and maintenance of implant stability are momentous for successful clinical outcome [4]. Therefore, measuring the implant stability is an essential method for evaluating the success of an implant[5].

Two terms; the primary and secondary implant stability are related to implant therapy. Primary stability is represented the mechanical engagement of an implant with the surrounding bone while bone regeneration and remodeling phenomena determine the secondary (biological) stability of the implant [6,7]. Primary stability is positively associated with a secondary stability [8]. Extent of implant stability may also depend on the statues of surrounding tissues [9]. Bone quality and quantity, implant geometry and surgical technique adopted among the predominant clinical factors that affect primary stability [10]. Therefore, it is mandatory to assess the implant stability at different time-points to ensure a successful osseointegration [11].

The successful treatment of dental implants is considered to be affected by both the quality and the quantity of present bone for dental implant placement. Studies have shown higher failure rates for implants placed in bone with poor quality and quantity. Therefore, a precise evaluation of bone density is essential before implant placement [12].

Historically, the gold standard method used to assess the degree of osseointegration was histologic or microscopic examination [13]. However, due to the invasiveness of this method and related ethical topics, various other methods of examination have been proposed: clinically testing for mobility with the help of blunted instruments, reverse torque, cutting torque resistance, radiographs and resonance frequency analysis (RFA) [14].

Materials and methods

Retrospective study for the patients receiving dental implants in dental implant unit in educational hospital of collage of dentistry /Baghdad University for past three years, during period of October 2012- October 2015. During this period 152 patients (104 females, 48 males) with 299 dental implants included in this study, 5 dental implants in 4 patients failed, so 294 dental implant included in the stability study. The data collected from 7 researches that mate the inclusion criteria which are : recording the data of age, gender, implant length, diameter, location of implant, and bone quality (bone density), recording type of surgical procedure and measurement of stability (primary and secondary).The dental implant fixtures used: •Dental implant (Implantium , Dentium, Seoul, Korea) •Dental implant (Maxicell, Nucleoss, Turkey). Two-stage endosseous dental implant , Screw type, surface modified by TiO2-Sandblasting with Large grit and Acid etching (S.L.A.) surface, Pure titanium, Implant length used 8mm,10mm 12mm and 14mm,Implant diameter used 3.4mm, 3.8mm 4.3 and 4.8mm. Cases with 4-6 months follow up, from the surgical procedure until complete

healing and finishing prosthetic part; so to determine the survival and failure rate, only early implant failure estimated in this study (implant that fail to Osseointegrate with bone or fail before occlussal loading)

Groups of the data: In this study, the researches selected grouped according to surgical procedure or material used. These groups are: •Strait forward dental implant procedure with two groups, study group using bone morphogenetic proteins (BMP) and control group without any additive material. • Complex dental implant procedure, Immediate implants placement in fresh extraction socket with use of bone substitute (β – tricalcium phosphate) and collagen barrier membrane. • Complex dental implant procedure, Ridge splitting with using of piezo-surgical units and with use of bone substitute (β – tricalcium phosphate) and collagen barrier membrane. •Strait forward dental implant procedure, with reading of stability during healing period. Strait forward dental implant procedure with two groups, study group using simvastatin drug (test drug) and control group without any additive material. •Strait forward dental implant procedure with two groups, study group using platelet rich plasma PRP and control group without any additive material. •Strait forward dental implants prepared by piezo-surgical units.

Implant stability and bone density measurement: All cases in this study evaluated with Osstell devise at time of surgery and during healing period to evaluate changes in implant stability and effect of the material used or type of surgical procedure on implant stability. Bone density measured by computed tomography (CT scan) in Hounsfield unit (HU) and according to position in dental arch, clinically according to Mish criteria

Results and Discussion

One of the aims of this study was evaluation of factors that affect stability of dental implant. This study need to identify what variables that had direct effect on primary and secondary stability, and which intervention had effect to reduce healing time with good secondary stability that permit use of final prosthesis with minimum healing time. The controversy present because this study is retrospective study and data collected from other studies, so it cannot depends 100% because may by presence of bias from researchers towards their studies.

Study sample

In these study 152 patients (104 females, 48 males) with 299 dental implants included. Due to large data, many variables included in this study and different procedure and material used, thus divided to 7 different groups: control group and 6 interventions group which are: BMPs, Immediate dental implant, Ridge splitting procedure, Test drug, PRP and Piezosurgery.

Distribution of main variables in study groups:

1. Age: The control group with range (21 to 65) years and mean age= 42.4 years, BMP group with range (33 to 65) years and mean age=48.1 years , Immediate dental implant group with range (23 to 66) years and mean age= 40.9 years, Ridge splitting group with range (18 to 60) years and mean age=42.7 years, Test drug group with range (40 to 48) years and mean age=42.4 years, PRP group with range (22 to 60) years and mean age=41.9 years and

Piezosurgery group with range (19 to 51) years and mean age=36.4 years. The differences of age observed between groups were statistically significant, p= 0.006.

2. **Gender**: Control group with 34 male and 65 female, BMP group with 9 male and 15 female, Immediate dental implant group with 19 male and 25 female Ridge splitting group with 12 male and 45 female, Test drug group with 14 female, PRP group with 7 male and 7 female and Piezosurgery group with 8 male and 34 female. The gender composition was also significantly different between study groups, p= 0.006.
3. **Position (maxilla Vs mandible)**: Control group with 60 in maxilla and 39 in mandible, BMP group with 17 in maxilla and 7 in mandible, Immediate dental implant group with 39 in maxilla and 5 in mandible, Ridge splitting group with 29 in maxilla and 28 in mandible, Test drug group with 14 in maxilla and 0 in mandible, PRP group with 8 in maxilla and 6 in mandible and Piezosurgery group with 24 in maxilla and 18 in mandible .The position of dental implants was significantly different between study groups according to the specific jaw involved (maxilla Vs mandible), p<0.001
4. **Location**: The implant location in control group 67 posterior and 32 anterior, BMP group 13 posterior and 11 anterior, Immediate dental implant group 15 posterior and 29 anterior, Ridge splitting group 30 posterior and 27 anterior, Test drug group 7 posterior and 7 anterior, PRP group 11 posterior and 3 anterior and Piezosurgery group 29 posterior and 13 anterior. The location in the jaw, whether anterior or posterior significantly different, p= 0.003.
5. **Bone density**: All groups with median density D3 except Piezosurgery group with D2. The bone density was also significantly different between the study groups, p<0.001.

The differences in (age, gender, location -anterior or posterior-, position -maxilla or mandible- and bone density) between groups related to : The data collected from 7 researches that different in inclusion and exclusion criteria. For example : simvastatin drug used in female above 40 years because in this age female at high risk to have osteoporosis and Ridge splitting used in resorbed ridge that have width less than 4mm , so the bone density high in this group.

Primary stability

1. Achieving high primary stability in control and interventions groups

Primary implant stability is essential for implant survival, thereby avoiding the formation of a connective tissue layer between implant fixture and bone, so ensuring bone healing. Not only the quantity and quality of bone predict primary stability, but the surgical procedure (relation between drill size and implant size). Optimal implant stability is mainly essential in bone of low density. Expression is reflected as the “password of Implant Integration Account.” If the primary stability is respectable, implant can be loaded rapidly [(15)].

The incidence of high ISQ at this point of time was highest and ranked first in (PRP) and Piezosurgery groups (78.6% and 76.2% respectively). The high primary stability values in Piezosurgery could be explained by piezoelectric device drill size may be smaller than implant fixture size. The test drug and control group followed in its stability ranked second (64.3% and 62.6% respectively). The Immediate

dental implant and BMPs ranked third, with high implant stability achieved in 46.5% and 45.8% of cases respectively. This low primary stability values in immediate dental implant could be explained by little bone present around implant and in the apical area only. The lowest incidence rate of high implant primary stability was observed with the ridge splitting procedure (28.1%). This due to few bone support around implant. Only the Ridge splitting procedure significantly reduced the risk of achieving high implant primary stability compared to control. This result due to little bone support around dental implant.The (BMPs) and Immediate dental implant associated with reduction in achieving the required target of high stability but fail to show statistical significance. Test drug, (PRP) and Piezosurgery groups on the other hand increased the risk of achieving high primary stability compared to control group. However not achieve the statistical significance.

2. Variable that effect primary stability

Implant location: Among the variables only the posterior location of the implant in a specific jaw significantly increased the possibility of achieving high stability compared to an anteriorly located implant (P=0.025). The result of this study are in agreement with other study that found that primary implant stability was higher in posterior than in anterior regions [16]. They explained their results by the fact that they used wider implants in posterior regions than in anterior regions. On the other hand, this study results disagree with the results of other that found that implant stability significantly affected by implant arch location, being higher in the anterior than the posterior area. In the anterior area, the thick cortical and the dense trabecular bone will increase the stability [17]. Length and Diameter: Length and Diameter fail to be significantly affected. The results were disagreement with others that found a significant correlation of implant diameter with implant stability, and in agreement with no statistically significant correlation was found between implant length and implant stability[18,19]. Jaw location: Maxillary location compared to mandible fail to be statistically significant effect. This study results were disagrees with others who found higher ISQ values in the mandible compared to the maxilla and were statistically significant [20,18]. The results coincides with other who found that the ISQ of the mandibular and maxillary implants showed no statistically significant differences, although lower ISQ values were always found in the maxilla [17]. Bone Density: showed no statistically significant differences. The results disagree with the results of other who obtained more primary implant stability in areas with greater bone density in the CT. Thus, the greater the HU value, the greater is the primary stability measured in ISQ values. They suggested bone density by HU as a method to predict primary stability[21]. Age and gender: Age and gender fail to achieve statistically significant. The study results were in agreement with other who found that the gender of the patients not significantly effective in implant stability according to ISQ values[18]. The result of this study in general disagrees with other that found; ISQ of the mandibular and maxillary implants was significantly different, Implant location did not affect the ISQ significantly, Bone quality affected implant stability significantly, the implant diameter did not affect the ISQ and Implant length was not a parameter influencing primary stability[22].

Secondary stability in control group

1. Achieving high implant secondary stability among control group:

The stability of implant at 70 ISQ or more is considered an implant with high ISQ [(23)]. About half of control group (51.5%) achieved the high stability after 2 months with mean=68.6. This disagree with other that achieving high stability with mean= 73.55. More than half of control group (59.6%) achieved the high stability after 3 months with mean=70.8. This disagree with other that found 100% achieved the high stability (more than 70 ISQ) with mean =75.60 ; however there are differences in number of patients that only 15 implant in mandible and this study 99 implant in both jaws [24]. High percentage (97.8%) achieved the high stability among control group after 4 months of follow up. The stability of implants assessed in this study was affected by healing time as shown in previous studies, that during healing the stability decrease first after 6-8 weeks then going to increase, because changing from mechanical (primary) stability to biological (secondary) stability [20].

2. Variables affecting implant stability among control group:

Some authors recommend that using longer and wider implants increase primary stability due to the increased bone-implant connection surface area [16]. And other suggest that bone density and implant stability is lower in the posterior area; for this reason the posterior implant success rate is less than the anterior [25]. In the anterior area, the thick cortical and the dense trabecular bone will increase primary stability. In this study implant length and posterior location in the jaw had a statistically significant effect on the achieving high stability after adjusting for the remaining explanatory variables. P= 0.033 for length of implant and P= 0.049 for location. Other variables (age, gender, diameter, mandibular location and bone density) failed to be statistical significance. This study disagrees with other that found gender be significant ($p<0.05$); women showed higher implant stability than men. In relation to location within the dental arch, statistical analysis showed higher ISQ values for anterior implants than posterior fixtures ($p<0.05$). In addition, other variables (age, diameter, mandibular location and bone density) failed to be statistical significance[17].

Achieving high implant secondary stability among intervention groups

1. BMPs group: The mean of primary stability (68.3),(70.8 %) achieved high stability at the end of 2 months follow up with mean=72.1. High percentage (91.7%) achieved high stability at the end of 3 months follow up with mean= 75.4. This study showed that the stability patterns were noticeably different from baseline to 3 months of follow up. The mean average ISQ changed at the 2 months after implant placement compared to the primary stability then the mean value increased at the 3 months to reach a value higher than the primary stability.

2. Immediate dental implant group: The mean of primary stability (64.8) .More than half (52.4%) achieved high stability at the end of 4 months follow up with mean= 69.4. This results showed that the stability patterns were different from baseline to 4 months of follow up but not change the category of mean stability.

3. Ridge splitting procedure group: The mean of primary stability=62.2. More than half (56.1%) achieved high stability at the end of 4 months follow up with mean =70.1 with difference from base line.These results were in coincidence with other study[26] .

4. Test drug group: The mean of primary stability=72.8. High percentage (85.7 %) achieved high stability at the end of 2 months with mean =75.3 and all the group (100%) achieved high stability at the end of 3 months with mean =79.5. with difference during healing period without decrease stability in 2 months .

5. PRP group: The mean of primary stability (73.2) .(64.3%) achieved high stability at the end of 2 months with mean= 73.2 and (85.7%) achieved high stability at the end of 3 months with mean=74.3. This results showed that the stability patterns were not noticeably different from baseline to 3 months of follow up. The mean average ISQ not changed at the 2 months after implant placement compared to the primary stability then the mean value increased at the 3 months to reach a value slightly higher than the primary stability but still not significant. This result in agree with other that found not noticeably different in ISQ value during healing period[27].

6. Piezosurgery group: The mean of primary stability (74.3) . (61.9 %) achieved high stability at the end of 2 months with mean=72.6 and (83.3%) achieved high stability at the end of 4 months with mean=76.7. These results showed that the stability patterns were slightly different from baseline to 4 months of follow up. The mean average ISQ decrease at the 2 months after implant placement compared to the primary stability then the mean value increased at the 4 months to reach a value slightly higher than the primary stability. These results represent a normal change that occurs during the healing period and the current osseointegration process at the bone-implant interface, and this process could reproduce the transition from the primary mechanical stability to the secondary biological stability as a result of osteoclastic activity during the early postoperative healing period cause decrease in the early mechanical stability and there is no enough bone formed to maintain implant primary stability followed by modeling and remodeling of the surrounding bone[28].

changes in ISQ during healing period:

Implant with low primary stability revealed a significant increase in stability during healing, in comparison; implant with high primary stability lost some stability over time [29]. •The control group showed a statistically significant decrease in mean ISQ after two months compared to a mean ISQ immediate after surgery. In addition, after three and four months of surgery, there was a statistically significant increase of compared to baseline. (P= 0.044, P=0.031 and P<0.001).•The BMPs group showed a statistically significant increase in mean ISQ after two months compared to a mean ISQ at baseline. In addition, after three months of surgery, there was a statistically significant increase compared to baseline. (P=0.009 and P<0.001). This result in agreement with other, who found significant increase in ISQ value compared with control group after 2 months[30].•The Immediate dental implant group showed a statistically significant increase in mean ISQ after four months compared to a mean ISQ at baseline. (P=0.002).•The Ridge splitting procedure group showed a statistically significant increase in mean ISQ after four months compared to a mean ISQ at baseline. (P<0.001).•The Test drug group showed a marginal and statistically insignificant increase in mean ISQ after two months compared to a mean ISQ at baseline. In addition, after three months of surgery, there was a statistically significant increase

compared to baseline. (P= 0.26, P=0.003).•The PRP group showed no important or statistically significant change in in mean ISQ after two months of surgery compared to baseline. In addition, a marginal and statistically insignificant increase in mean ISQ after three months of surgery. (P= 0.98, P=0.43).•The Piezosurgery group showed no important or statistically significant change in in mean ISQ after two months of surgery compared to baseline. In addition, a marginal and statistically insignificant increase in mean ISQ after four months of surgery. (P= 0.19, P=0.05).Comparing the changes observed in mean ISQ after two months of surgery between each intervention group and the control group showed that only the BMPs intervention group was associated with a statistically significant higher positive increase in mean ISQ compared to the observed marginal reduction among controls.(P= 0.035, P=0.08). The remaining intervention groups showed no statistically significant differences in mean changes observed after 2 months of surgery. Comparing the changes observed in mean ISQ after three months of surgery between each intervention group and the control group showed no statistically significant differences. Comparing the changes observed in mean ISQ after four months of surgery between Piezosurgery and the control group showed no statistically significant difference. The same applies to the comparison between immediate dental implant and Ridge splitting procedure after 4 months of surgery.

Comparing ISQ between interventions groups and control group

Primary stability: Compared to control group the mean ISQ at surgery showed no important or statistically significant difference from that of BMPs, Test drug, PRP and Piezosurgery. P=1 and 0.38 respectively. Regarding PRP; the result coincides with other that found no statistically significant differences observed between the test and control groups at a base line[31]. Regarding Piezosurgery, the result coincides with other that found in experimental study: Piezosurgery and conventional implant bed drilling procedure do have similar mechanical consequences regarding primary stability with high ISQ values; there was no statistically significant difference in the ISQ values when comparing conventional osteotomy to piezosurgery[32]. Immediate dental implant and Ridge splitting procedure showed a statistically significant lower ISQ at baseline than the control group. P=0.011and P<0.001 respectively. Regarding Immediate dental implant; the result coincides with other that found Implants placed at healed sites showed higher ISQ values compared to immediate implant placement, these differences in the mean ISQ values were statistically significant (p<0.001)[33].

2 months of surgery: Compared to control group the mean ISQ after 2 months of surgery, The test drug showed a statistically significant higher ISQ compared to control group (P= 0.029), but Bone morphogenetic proteins (BMPs), Platelet-Rich Plasma (PRP) and Piezosurgery groups showed no statistically significant difference from that of control group.

3 months of surgery: Compared to control group the mean ISQ after 3 months of surgery BMPs and test drug showed a statistically significant higher ISQ by 4.6 and 8.7 compared to control group (P=0.037 and P<0.001respectively), (PRP) showed no important or statistically significant difference from that of control group

(P= 0.52). Regarding PRP this result in agreement with other, no statistically significant differences were observed between stability of implants measured in 2 groups after 3 months[31]. Regarding PRP and simvastatin drug, this is in agreement with others in their experimental study that found (and with limitation, because this study clinical and the other experimental histological study) by Conventional histological investigation (hematoxylin and eosin staining) shown that the simvastatin group showed indicators for mature bone tissue, whereas the PRP group showed the simultaneity of indicators for mature and immature bone tissue[34]. Regarding PRP and BMP; While most of the authors present favorable results using BMPs the disadvantages have to be revealed: One of them is high cost. Additionally, BMPs induce the development of osteoblasts and osteoclasts. This negative effect can be partly responded by combining the BMPs with PRP. Adding PRP to BMPs suppresses the osteoclast induction of BMPs, which counters to the development of newly grown bone. Thus, the amount of added signaling molecules can be reduced. Therefore, the clinical results can be enhanced and the costs decrease[35].

After 4 months of surgery: Compared to control group the mean ISQ after 4 months of surgery Piezosurgery showed no statistically significant difference in mean , P=0.9. This disagrees with other that state: There is a weak suggestion that ultrasonic implant site preparation by piezoelectric inserts does not affect the primary mechanical stability but could fasten the bone healing process and increase the secondary implant stability, faster than the traditional drilling technique[36]. Also the result disagrees with other, who found in experimental study that bone neo formation was more obvious in implant site preparations achieved with conventional instruments, nevertheless both the conventional and piezoelectric instruments promoted similar bone neo formation[37]. After 4 months Ridge, splitting procedure and Immediate dental implant showed no important or statistically significant difference. P=0.64. Regarding Immediate dental implant this is agreement with other that found there are no significant differences between the secondary stability of implants placed immediately compared to those placed at the healed sites[33]. See (Table 1).

Effect of interventions and variables on implant secondary stability

After 2 months : Among the controlling explanatory variables, the implant diameter was the strongest predictor of ISQ after 2 months (P <0.001). The implant length ranked second in its importance in deciding the ISQ(P =0.004). The mandibular location of the implant compared to maxilla ranked third in its importance (P=0.049). The effect of bone density classification failed to reach the level of statistical significance, its effect on ISQ occupied the fourth rank (P= 0.12). Gender, age and antero-posterior position of the implant occupied the last order in importance in deciding the ISQ after two months of surgery, but these effects were not significant statistically.(P= 0.06), (P= 0.13) and (P= 0.23) respectively. Compared to control group the effect of test drug in achieving a higher ISQ after two months of surgery was statistically significant(P <0.001). The beneficial effect of Platelet-Rich Plasma (PRP) and Bone morphogenetic proteins (BMPs) in obtaining a higher ISQ compared to control group. but it fail to be statistically significant (P=0.048) and (P=0.07) respectively. The effect of Piezosurgery compared to control

group was marginal and not significant statistically. (P=0.44). (P=0.44). See (table 2)

After 3 months: Implant length effect stability after 3 months and was statistically significant (P=0.002). Mandibular location effect stability and was statistically significant (P=0.003). Implant Diameter effect stability and was statistically significant (P=0.02). Male gender effect stability and was statistically significant (P=0.049). Implant location, Age and Bone Density fail to be statistically significant. This result partially coincides with other regarding mandibular location and bone density, and disagreement regarding implant length and diameter of implant and implant location. The ISQ of the mandibular and maxillary implants was different, difference between jaws was significant. Implant localization, implant diameter and implant length did not affect implant stability. Bone type did not affect implant stability after 3 months[22]. Compared to control group the test drug achieving a higher ISQ after three months of surgery and was statistically significant (P<0.001). BMPs obtaining a high ISQ compared to control group and ranked second among the tested interventions and was statistically significant (P=0.005).PRP obtaining a high ISQ compared to control group and ranked third among the tested interventions but was statistically not significant(P=0.11).

After 4 months: Compared to control group the Piezosurgery was associated with a statistically significant lower ISQ after four months of surgery. (P=0.004). Implant Diameter effect stability and was statistically significant. (P<0.001). Implant location (Anterior Vs Posterior), Mandibular location compared to maxilla, Age, Implant length and Male gender compared to females fail to be statistically significant. Compared to control group the Immediate dental implant procedure was associated with a lower ISQ after four months of surgery, This effect was not significant statistically. (P= 0.16).Implant diameter and Implant length had statistically significant effect. (P= 0.003 and P=0.014).Age, mandibular location compared to maxilla, gender and bone density fail to be statistically significant.

Variables effect stability in study groups after two months of surgery (secondary stability):

Although Primary stability, the gold standard factor determining implant success, is not the solitary requisite and good osseointegration is promising if biologic stability is achieved without a depression in the healing phase. Obtaining secondary or long-term stability is the recent password for predictable implant outcome [38]. Among the variables only the diameter and length significantly increased implant stability after two months of surgery (P= 0.011 and P<0.001). The other variables; bone density, mandibular location, Posterior position and Female increase the stability but it is not statistical significance. The effect of age was not statistical significance.

Survival rate

One of the purpose of this study was to evaluate the survival rate for dental implants, which was investigated on the basis of host related factors such as patient age and gender. Implant placement site related factors such as position in jaw and bone quality (bone density). Surgery related factors including: primary stability. Implant fixture related factors, such as length and diameter of an implant fixture. Cumulative survival rate achieved in this study was (98.33%) and failure rate (1.67%), Average

observation period was 6 months. High survival rate in this study coincides with previous retrospective studies; such as Noda et al in 2015 [39] that survival rate achieved in this study was (98.5%) and early failure rate (1.5%). And agreement with Jang et al. in 2011 [40] that survival rate achieved in this study was (96.33 %). And agreement with Wang in 2013 [41] that survival rate achieved in this study was (98%). However, there is a difference in the follow up periods as well as in treatment protocol when compared with these studies. Some presented that when patients age increases, failure rate had a tendency of increase 42. Other study revealed that gender is an influencing factor, reported that failure rate in male was higher than in female [43,44].There were no significant effect between the related factors (age, gender, diameter of implant, length of implant, bone density, jaw and position in dental arch) and failure rate of dental implant in this study. This study coincides with previous retrospective study Noda et al [39] that found no significant effect between these factors and early failure rate of dental implant but found that the smoking only the risk factor (table 3).

Conclusion

1. Control group achieving the high stability after 4 months of follow up. Among the variables that affect the control group: implant length and posterior location in the jaw had a statistically significant effect on achieving high stability.
2. Each intervention groups and control group showed dipping in ISQ, except the (BMPs) group showed a statistically significant increase in ISQ after 2 months compared to ISQ at baseline.
3. Comparing the changes during healing period observed in mean ISQ after 2 months of surgery between each intervention group and the control group showed that only the (BMPs) intervention group was associated with a statistically significant higher positive increase in mean ISQ.
4. Among the interventions groups the Ridge splitting and immediate dental implant procedure reduce implant primary stability compared to control. And among the variables that affect primary stability only the posterior location of the implant in a specific jaw significantly increased the possibility of achieving high stability.
5. Implant diameter, implant length and mandibular location and among the intervention test drug achieving a higher ISQ after two months of surgery.
6. Implant length, mandibular location, implant diameter and male gender increase stability and was statistically significant, And among the intervention test drug and (BMPs) obtaining a high ISQ and was statistically significant after 3 months.
7. Implant Diameter increase stability, but the Piezosurgery was associated with a statistically significant lower ISQ after 4 months.
8. Implant diameter and implant length had statistically significant effect after 4 months to immediate dental implant and ridge splitting procedure.
9. Immediate dental implant lower primary ISQ but showed no difference in secondary stability when compared with control group (compare the immediate dental implant with delay type implant).
10. Test drug and BMP reduce the healing time and improve stability.

11. Bone Density had no effect on primary stability and secondary stability.
12. Cumulative survival rate achieved in this study was (98.33%) and failure rate (1.67%).
13. There were no significant effect of any variables on failure rate of dental implant in this study.

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(Table 1) The effect of selected interventions compared to control for ISQ at selected time intervals.

	control	BMP	Immediate dental implant	Ridge splitting procedure	TEST DRUG	PRP	Piezosurgery	p
1-ISQ-at surgery								<0.001
Range	(53.5- 85)	(60- 82)	(46.5- 81)	(4 -81)	(61.5-81)	(51 -82)	(55.5 -85)	
Mean	70.5	68.3	64.8	62.2	72.8	73.2	74.3	
SD	7.5	6.2	9.6	12.5	7.4	8.1	6.4	
SE	0.75	1.26	1.46	1.65	1.98	2.17	0.99	
No.	99	24	43	57	14	14	42	
Difference in mean compared to control	Reference	-2.2	-5.7	-8.3	2.3	2.7	3.8	
Cohen's d		-0.30	-0.70	-0.86	0.31	0.36	0.53	
P(Bonferonni t-test)		1[NS]	0.011	<0.001	1[NS]	1[NS]	0.38[NS]	
2-ISQ -after 2 months			…….	……..				0.003
Range	(51 -85.5)	(55-86.5)			(58 -82.5)	(63 -80)	(54 -86.5)	
Mean	68.6	72.1			75.3	73.2	72.6	
SD	7.8	6.6			6.6	5.9	9	
SE	0.79	1.34			1.78	1.58	1.4	
N	99	24			14	14	42	
Difference in mean compared to control	Reference	3.5			6.7	4.6	4	
Cohen's d		0.46			0.87	0.61	0.49	
P(Bonferonni t-test)		0.49[NS]			0.029	0.4[NS]	0.05[NS]	
3-ISQ -after 3 months			……	……			……..	<0.001
Range	(52.5- 87)	(59.5-89)			(71- 83.5)	(64- 81)		
Mean	70.8	75.4			79.5	74.3		
SD	7.8	5.9			3.9	5.4		
SE	1.05	1.2			1.05	1.45		
No.	55	24			14	14		
Difference in mean compared to control	Reference	4.6			8.7	3.5		
Cohen's d		0.63			1.21	0.47		
P(Bonferonni t-test)		0.037			<0.001	0.52[NS]		
4-ISQ -after 4 months		……			……..	……		0.9 [NS]
Range	(69.- 84)		(46.5 -81)	(48.5- 81)			(54 -86.5)	
Mean	76.8		69.4	70.1			76.7	
SD	4.2		7.5	8			7.3	
SE	0.63		1.16	1.06			1.13	
No.	44		42	57			42	
Difference in mean compared to control	Reference		0.62	0.7			-0.1	
Cohen's d			0.64[NS]	0.09			-0.02	

(Table 2) Multiple linear regression model with ISQ during healing period as the dependent (response) variable and selected explanatory variables including the effect of selected interventions.

After 2 months					**After 3 months**				**After 4 months Piezosurgery**				**After 4 months Immediate dental implant**			
	Regression coefficient (RC)	**P**	**Standardized Coefficients (SC)**	**95.0% Confidence Interval for regression coefficient (CIRC)**	**RC**	**p**	**SC**	**(CIRC)**	**RC**	**P**	**SC**	**(CIRC)**	**RC**	**P**	**SC**	**(CIRC)**
(Constant)	36.9	<0.001		(18.77 to 55.03)	40.7	<0.001		(20 to 61.46)	61.7	<0.001		(43.35 to 80)	19.1	0.32 [NS]		(-18.73 to 56.84)
Implant Diameter (mm)	7.6	<0.001	0.373	(4.29 to 10.91)	4.6	0.02	0.232	(0.73 to 8.45)	6.7	<0.001	0.485	(3.42 to 9.97)	10.3	0.003	0.342	(3.52 to 17.14)
Age (years)	-0.08	0.13 [NS]	-0.101	(-0.18 to 0.02)	0.002	0.98 [NS]	0.002	(-0.13 to 0.13)	-0.05	0.38 [NS]	-0.082	(-0.16 to 0.06)	0.03	0.64 [NS]	0.044	(-0.08 to 0.13)
Implant length (mm)	1.1	0.004	0.195	(0.35 to 1.78)	1.4	0.002	0.268	(0.54 to 2.24)	0.3	0.43 [NS]	0.072	(-0.42 to 0.96)	1.4	0.014	0.333	(0.29 to 2.56)
Mandibular location Vs maxilla	2.3	0.049	0.139	(-0.02 to 4.66)	4.6	0.003	0.286	(1.59 to 7.64)	1.7	0.16 [NS]	0.146	(-0.67 to 4.11)	3.7	0.22 [NS]	0.228	(-2.21 to 9.66)
Bone Density D3 Vs D2 D4 Vs D2	-1.6 -3.2	0.12 [NS]	-0.135	(-3.53 to 0.39)	-0.8 -1.6	0.46 [NS]	-0.077	(-3.06 to 1.38)	-3.2 -6.4	0.004	-0.375	(-5.3 to -1.02)	-0.8 -1.6	0.71 [NS]	-0.061	(-5.02 to 3.44)
Male Vs females	-2.3	0.06 [NS]	-0.129	(-4.63 to 0.1)	-3.0	0.049	-0.192	(-5.96 to -0.01)	-0.7	0.54 [NS]	-0.057	(-3.15 to 1.67)	-1.1	0.5 [NS]	-0.066	(-4.3 to 2.11)
Implant location (Anterior Vs Posterior)	-1.7	0.23 [NS]	-0.100	(-4.47 to 1.09)	-2.0	0.2 [NS]	-0.129	(-5.05 to 1.09)	-2.7	0.08 [NS]	-0.216	(-5.63 to 0.32)	-4.5	0.018	-0.292	(-8.26 to -0.79)
BMPs Vs control	3.1	0.07 [NS]	0.127	(-0.23 to 6.4)	4.4	0.005	0.254	(1.38 to 7.45)	…..	…..	…..	…..	…..	…..	…..	…..
Test drug Vs control	7.1	<0.001	0.231	(3.06 to 11.2)	9.3	<0.001	0.430	(5.52 to 12.99)	…..	…..	…..	…..	…..	…..	…..	…..
(PRP) Vs control	4.0	0.048	0.128	(0.03 to 7.89)	3.0	0.11 [NS]	0.138	(-0.68 to 6.62)	…..	…..	…..	…..	……	……	……	……
Piezosurgery Vs control	1.3	0.44 [NS]	0.065	(-1.99 to 4.51)	…..	……	……	…..	-4.6	0.004	-0.389	(-7.65 to -1.47)	……	……	……	…….
Immediate dental implant Vs control	……	…..	…..	……	…..	……	……	……	……	……	…..	……..	-2.8	0.16 [NS]	-0.181	(-6.78 to 1.13)

(Table 3): The implant failure rate among control group and variables affected.

	No failure		Failure		Total		
	No.	%	No.	%	No.	%	P
Age group (years)							0.21[NS]
<30	19	100.0	0	0.0	19	100.0	
30-49	47	97.9	1	2.1	48	100.0	
50+	33	91.7	3	8.3	36	100.0	
Gender							0.13[NS]
Female	65	98.5	1	1.5	66	100.0	
Male	34	91.9	3	8.1	37	100.0	
Implant location (Anterior Vs Posterior)							0.31[NS]
Posterior	67	94.4	4	5.6	71	100.0	
Anterior	32	100.0	0	0.0	32	100.0	
Jaw							1[NS]
Maxilla	60	95.2	3	4.8	63	100.0	
Mandible	39	97.5	1	2.5	40	100.0	
Bone Density classification							1[NS]
D1/D2	10	100.0	0	0.0	10	100.0	
D3/D4	89	93.8	4	6.2	93	100.0	
Implant length (mm)							0.95[NS]
Range	(8 to 14)		(10 to 12)				
Mean	10.9		11				
SD	1.5		1.2				
SE	0.15		0.58				
No.	99		4		103		
Implant Diameter (mm)							0.052[NS]
Range	(3.4 to 4.8)		(3.8 to 4.8)				
Mean	3.8		4.2				
SD	0.4		0.5				
SE	0.04		0.24				
No.	99		4		103		