Comparative Analysis of the Effectiveness of Standard Treatments and Piezosurgery in Dentistry

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Abstract

The use of piezosurgery in dentistry is increasingly widespread, but a comparative analysis of this relatively new method with traditional osteotomy techniques is necessary. The work aims to compare effectiveness of standard dental treatment methods with piezosurgery. The study was conducted in 2018-19 at the Institute of Dentistry at Sechenov University and Peoples Frendship University of Russia. A total of 178 patients diagnosed with acquired edentulism were subdivided into two groups: Group 1 with standard osteotomy methods used, Group 2 with piezosurgical methods used. Only 4% of Group 2 patients and 60% of Group 1 patients ($p \leq 0.0001$) experienced bleeding. Group 2 patients were discharged within the first two days of surgery and group 1 patients were discharged within four days ($p \leq 0.05$). The use of piezoesurgical techniques reduces probability of complications by a factor of 4 in Group 2 versus Group 1. Postoperative rehabilitative period in Group 2 was 20% shorter. Analysis of reoparodontogram indicated that vasoconstriction of regional vessels was observed in Group 2 and was eliminated one month after the operation.

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Introduction

Contemporary dentistry techniques which are not yet widespread include piezosurgery. The ultrasonic dental hard tissue handpieces were developed by the team of clinicians so that the crown treatment can be completed flawlessly in aesthetically relevant areas. Professor Domenico Massironi has developed, in collaboration with Komet, handpieces for dentin treatment and subgingival preparation for fixed restorations.

Piezosurgery is used in dental procedures such as dental extractions, bone transplants and dental implants.[1] The essence of the method is that all necessary incisions are performed with ultrasound, and there is no trauma to the gums and other soft tissues, vessels and nerve endings, as is often the case with standard dental surgery.[2] Another characteristic of the method is the accuracy of the incision, which is achieved thin and in the desired area. The benefits of the method include a guaranteed outcome consistent with the prognosis, and these benefits are adhered to for dental implants and dental treatments. Furthermore, the number of traumas in the oral cavity during piezosurgery is minimal, the surgery itself is painless, fast and accurate in its performance.[3] Another benefit is the antibacterial effect of ultrasound and the ability to manipulate teeth in the most inaccessible areas.[4,5] Patients with piezosurgery have faster wound healing, no bleeding or edema, which significantly shortens their rehabilitation period.[6,7] In piezosurgery, ultrasonography is used to make a small incision or hole so that a small piece of tissue can be cut. By doing this, the ultrasound producing device is located at a distance from the operated surface in the patient's oral cavity without coming into contact with it. Ultrasound may cut through even the densest structure of the tissue, with the surrounding areas of soft tissue is not traumatized. This, along with the absence of pain, is the basic difference between piezosurgery and standard surgery with a drill.[8]

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The disadvantages of piezoelectric surgery include the high cost of services, as the equipment is very expensive, the higher the presence of highly qualified and trained personnel is a prerequisite. Nonetheless, the popularity of the method is continuously increasing.

As already mentioned, one of the advantages of piezoelectric surgery is its accuracy and the ability to function even in hard-to-reach areas. In particular, piezosurgery has been shown to be a good method for the elimination of third molars.[9] When standard methods such as the G.D. Zhitnitsky method were employed, severe bone and soft tissue trauma was observed. The frequency of inflammatory processes may reach up to 35% of all cases during the post-operative period. The piezosurgical procedure facilitated the regenerative processes. In particular, there was primary rather than secondary tension in wound healing, no recurrence, and the total rehabilitation period was halved.[10]

Still, for some patients, piezosurgery is not recommended as the optimal method. These include patients with diabetes mellitus, oncology, severe nervous system disorders, blood clotting problems, and the presence of a pacemaker. Other contraindications include the presence of fillings in the tooth. When using ultrasound, there is a high risk of damaging the filling material, so a highly qualified specialist is required when working with such a device.

Besides piezoesurgical methods, a relatively new and effective method is the periotome method (Luxator), which has proved its worth in dental extraction. This method is likewise characterized by painlessness and low tissue traumatizm. The particular feature of the ultrasonic method is the possibility of inserting it parallel to the root of the tooth, between the cement part and the periodontal ligaments, and then the instrument moves in an alternating movement. This results in tooth separation from the periodontal fibres and painless tooth extraction.[11-13]

Piezosurgery is widely used not just in dentistry, but also in bone surgery generally. This method is the best alternative to traditional chisels, trepannes, borers, drills, and burr machines (mechanical and electric). The use of low-frequency ultrasound tools created holes of the required size, with smooth, uniform edges around the perimeter during the operation. The disadvantages include the probability of heating the handpiece of the tool up to 140 ℃ in case of prolonged and continuous operation. Such heating can result in charring of the edges of the hole in the bone and therefore considerably delay healing in the postoperative period.[14,15] For this reason, it is advisable to cool the handpiece of the instrument into saline solution, but again this takes time. Although some authors have noted an increase in the temperature of the ultrasound knife relative to that of the drill and piezoelectric device, the structure of the osteocytes, however, has not been disrupted in cytological investigations.[16]

Lack of proper anesthesia in patients is dangerous and can result in the development of various complications due to the body's stress response to pain.[17] A reasonable choice of the method of local anesthesia, anesthetic, reduction of its dosage and concentration of vasoconstrictor, mandatory suction test, and the administration rate control will help avoid intoxication and complications caused by local anesthetics.[18]

Given the above and the relative novelty of the method, particularly in developing countries, studies comparing traditional methods in dentistry and the piezoesurgical method seem necessary. Although these works exist, they are insufficient.[19,20] Given the relevance of the subject, a definitive conclusion in favour of piezosurgery on standard methods requires a database on which such an unequivocal conclusion can be based. The present study tried to do this by comparing piezosurgery and standard techniques (mechanical devices) in a large sample of patients to provide the basis for an unambiguous conclusion. The authors suggest that the use of piezosurgery techniques is associated with a shorter post-traumatic period in patients.

This work aims to conduct a comparative analysis of the effectiveness of standard dental treatment techniques and piezosurgery method with a focus on the probability of complications. The objectives of the study were to: a) consider the probability of complications based on blood flow examination; b) study the course of the wound process when piezosurgery is used during blade implants seating. The authors assume that piezoesurgical methods will show greater efficiency and safety than standard osteotomy

methods.

Materials and methods

Materials

The study was carried out in 2018-19 at Sechenov University's Institute of Dentistry and Peoples Frendship University of Russia. The method of piezosurgery for surgical interventions (e.g., dental implants) has been used at this institute relatively recently, since 2015. In total, 178 patients who were diagnosed with acquired edentulism participated in this study. The age range was 26 to 66 and the average age was 43.5 ± 7.5 years. Patients with acquired edentulism were diagnosed with tooth defects (both included and terminal). According to Misch and Judi classifications, these dental defects were classified under Classes A, 3 and 2 and 3 of Group B. Patients were divided into groups as per the treatment method. Group 1 consisted of 88 patients with standard treatment (physiodispenser). Ninety patients in the second group (experiment) were treated surgically with piezoelectric apparatus. For monitoring purposes, normal values were taken from an additional 50 patients without positive periodontal history. Quantitative (number of manipulations) and qualitative (type of surgical intervention) data are provided in Table 1.

Type of operation	Number of patients total	Number of manipulations total	Number of patients, Group 1	Number of manipulations, Group 1	Number of patients, Group 2	Number of manipulations, Group 2	Total
1	116	148	58	68	58	80	528
2	6	8	2	2	4	6	28
3	56	82	28	38	28	44	276
Amount	178	239	88	108	90	130	832

Table 1. Quantitative and qualitative indicators for patients from groups 1 and 2.
Note. Column 1: 1 - blade implant installation, 2 - reinstallation of the implant, 3 - installation and sinuslift.

Study design

To improve the safety and quality of dental procedures, an articaine anesthetic was used with a vasoconstrictive concentration of 1:200000. A monoject plastic syringe was used during conductive anesthesia. The needles used for injecting anesthesia were 0.4 mm in diameter and 35 mm long, respectively. The cutting angle of the injector needle was "surgical blade". Local anesthetic has been injected at a speed of 1 ml per minute. To select the parameters of the injection needle, the injector, and the local anaesthetic, the "local anaesthesia examination procedure at the dental reception" was applied (certificate No. 020-010663, as of October 19, 2020; ISBN: 978-5-4472-9365-9). The computer program ‘Anesthesia Navigator’ was used for local anesthesia planning (Certificate No. 2020611218; Application No. 2019667283 as of December 16, 2019; State registration in the Register of Computer Programs as of January 27, 2020).

A written consent for participation in this study was signed with each patient. The agreement ensured the confidentiality and anonymity of the information. The study respected all the generally accepted moral and ethical standards of international practice.

The sinuslift operation was carried out as follows. A bone window was formed in the anterior wall of the maxilla sinus. At that, osteoplastic membranes and materials were used (manufacturers Osteomatrix and Platelet Rich Plasma), using the patient's autoblood, with bone height parameters up to 4 mm. In the case of a bone height between 4 and 8 mm, the procedure was performed similarly, but with the simultaneous seating of blade implants. This resulted in a reduction of the patient's rehabilitation period from 4 months to 6 months. If the height of the bone was between 8 and 10 mm, a closed soft sinuslifting was performed. Dental prostheses made by Konmet (Russian Federation) were used.

In the second group of patients, a piezoelectric apparatus was used (Piezosurgery White, Mectron, Italy) . In this case, a section of bone by cutting the mucosa and periosteum at the centre of the 1-3 mm alveolar ridge of the future implant bed was evaluated. This size was assumed to be the size of the future blade implant. The separation was made on either side to the depth of 10-15 mm, forming the edges of the incision. Then, for cutting tool orientation, the device was installed with the subsequent osteotomy to form the implant bed. For this purpose, the OT7 graduated nozzle of the piezoelectric scalpel produced by Piezosurgery was employed up to the depth, required for the installation of the analog implant. The EX1 and OT1 nozzles were used to smooth the implant bed and shape the cervix area of the implant. After the bottom of the implant bed was formed, a concentrate of platelets was positioned there.

The latter was produced from the patient's autoblood before surgery. The platelet implant was inserted with the aid of an implant guide. Upon completion of the operation, the surgical wound was sutured.

Study limitations

In this study, all patients were in the same dental clinic setting. At the same time, gender was not taken into account, which may be the basis for future studies. The group of patients using piezosurgery techniques included people who had no contraindications to the use of the method. All patients signed a written consent agreement for participation in the research, in which they were guaranteed confidentiality and anonymity of information. The study was conducted in accordance with international standards of ethics and morality.

Selection

When analyzing the data, the following parameters were under consideration: a) terms of infiltrate resorption; b) duration of exudation; c) terms in which the sutures were removed; d) overall treatment period. Hemodynamics and microcircular data were used as functional methods. The hemodynamic data were obtained from a P4-02 rheograph (Russia), on which the rheograms were recorded by a tetrapolar technique. The data was transferred directly from the rheographer to a computer.

When qualitatively characterizing reoparodontograms, the following elements were taken into account: anacrota, apex shape, cataracts, presence and degree of dicrotic wave, as well as by the presence and location of additional waves on the descending part.

The following rheoparodontogram parameters were used as quantitative features: rheographic index, peripheral vascular tonus reflective index, and wall elasticity indices. Furthermore, the peripheral resistance index was considered after 1, 3, 5, 7, 9, 11 days and 1 and 3 months after intraosseous implantation.

Parodontal tissue microcirculation was investigated using the Minimax Doppler K device (manufacturer SP Minimax). This is a non-invasive study based on ultrasound usage. The obtained Doppler curves were analyzed according to the following parameters: maximum blood flow while systolic and diastolic, average blood flow rate values, resistivity index, and Gosling index corresponding to peripheral resistance and pulsation in the above terms after intraosseous implantation.

Statistical analysis

The processing of the statistical data was carried out by means of Statistica v. 7.0 (StatSoft Inc., USA). The following statistical parameters were derived: arithmetic mean, mean error, standard deviation and error, coefficient of variation. Differences were considered significant at $p \leq 0.05$. Student's t-test was used to verify the significance of differences between the compared groups.

Results

It has been establsihed that during the post-operative period, patients in both groups did not complain about poor wellbeing. Body responses occurred only on the first day, with a slightly elevated body temperature (36.6±1.6 ℃). At the same time, external examination results indicated that collateral edema was observed in 45% of all patients examined.

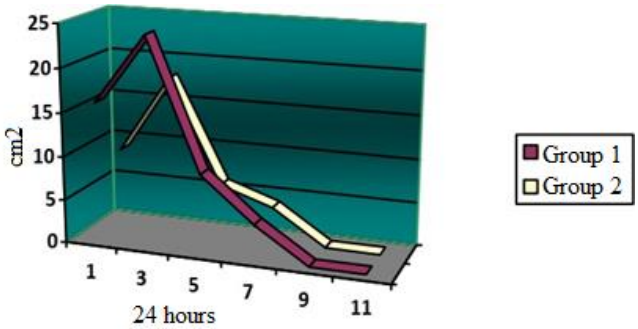

Figure 1. Indications of changes in the area of post-operative edema in patients of Groups 1 and 2.

During the postoperative period, patients in Group 2 had lower levels of edema (Fig. 2) in relation to patients in Group 1. Furthermore, in one third of the cases, no edema was observed in Group 2 patients. Decreased edema area values were observed on days 4-5 after surgery. A week later, no edema occurred in all patients in Group 2, while Group 1 had only 20%. It is noteworthy that edema disappeared completely only 2-3 days later in Group 1 patients, i.e. 9 to 10 days after the procedure.

Due to the denaturation effect of ultrasound on proteins, Group 2 patients bled

only 4% of the time, while Group 1 patients bled 60% of the time (p 0.0001).

Wound discharges occurred in less than 2 days in Group 2 patients, while Group 1 patients had an average of 4 days (Fig. 2, p ≤ 0.05). The suturing period varied because of the different time of wound repair. Thus, the average for Group 1 patients was 9.0±0.9 days; the average for Group 2 patients was 7.0±0.2 days (Fig. 2, p ≤ 0.05).

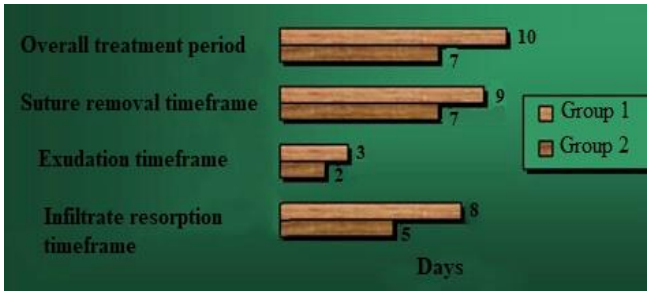

Figure 2. Wound repair timeframe in patients of Group 1 and Group 2.

Rheoparodontogram analysis revealed significant differences between patients in Groups 1 and 2. The values of the rheographic index in Group 1 were 33% higher than for Group 2 (p ≤ 0.01). The peripheral vascular tone index value was also 15% higher in Group 1 relative to Group 2, whereas the peripheral resistance index of Group 1 was one-third higher than that of Group 2 (p ≤ 0.01). The elasticity of the vascular walls of Group 2 was 9% greater than that of Group 1 (p ≤ 0.05). A month later, all indexes for both groups were equal, and three months later, all indexes matched the norm for all patients.

Blood flow rate parameters for patients in Groups 1 and 2 are shown in Table 2.

Parameter name	Group 1	Group 2	Normal range
Maximum blood flow while systolic.	0.83 ± 0.08*	1.05 ± 0.06**	1.42 ± 0.05
Maximum blood flow while diastolic.	0.22 ± 0.04**	0.45 ± 0.02**	0.53 ± 0.07
Average blood output	0.23 ± 0.03**	0.31 ± 0.02**	0.55 ± 0.04
Volumetric rate of blood flow while systolic.	0.004 ± 0.003**	0.013 ± 0.002**	0.026 ± 0.004
Volumetric rate of blood flow while diastolic.	0.001 ± 0.0004**	0.006 ± 0.0005**	0.009 ± 0.0006
Resistivity index	2.56 ± 0.14**	3.04 ± 0.19**	3.51 ± 0.02
Gosling Index	0.87 ± 0.05*	0.56 ± 0.04**	0.68 ± 0.03

Table 2. Evidence of microcirculatory bloodstream in the alveolar mucosa three days after surgery.

*Note: *differences are significant at p ≤ 0.01, ** at p ≤ 0.001*

All parameters showed significant differences at p ≤ 0.001 between both groups and normal range, except for two parameters: Gosling index and maximal blood flow rate while systolic (p ≤ 0.01). In all cases, the average parameters of Group 2 were higher than those of Group 1 and approached the standard on the third day following surgery.

Discussion

Piezosurgery was first introduced to dental surgery 12 years ago. Since that time, the methodology has started to spread widely among dental practitioners and clinics.[21] Piezosurgery is most common in the United States and Western Europe, becoming one of the most common techniques in dentistry.[22] The main field of application is the practice of in-patient and out-patient osteotomy. Piezosurgical techniques may be used in all cases of bone surgery.[23] Apart from dentistry itself, piezosurgery has found a broad application in other fields of surgery as demonstrated by reports of successful operations to restore the skull, airways, neoplasm removal, and operations in orbital cavities.[22] In addition, piezoesurgical techniques have found their application in plastic surgery, especially in operations involving changes to the facial profile.[24]

A study by Rashad et al.[25] found that the use of ultrasonic surgical systems in osteotomies reduced heat production compared to the standard osteotomy techniques in which a saw was used. These authors suggest that irrigation is a necessary and sufficient condition to prevent excessive bone overheating during osteotomy.

In general, the risk of death from complications and adverse effects of anesthesia is around 1 in 100,000 in Australia, Europe and the United States.[26] But the risks associated with local anesthesia, which do not cause direct harm to the patient, but result in undesirable effects, aggravating the result of dental intervention, are much more widespread. These risks are related to the rapid administration of local anesthetic,[27,28] the use of the diameter and length of the injection needle does not match the type of local anesthetic,[29] lack of suction test control. Reducing this risk contributes to the quality and safety of local anesthesia.

Piemonte[30] proposed using piezosurgery to prepare the bone bed during implant

placement. They demonstrated for the first time that ultrasound is more efficient than the usual methods used in dentistry. The results of this studt confirmed these findings, since patients not only had no pain, but also had a much shorter recovery period after surgery.

Somewhat earlier, Blus et al.[31] suggested the use of piezoesurgical techniques in sinus elevator surgery. At that, an augmentation of the maxillary alveolar process was performed in 34 patients over a five-year-period. This enabled to limit the risk of localized mucous perforation in the maxillary sinus. This study showed that nearly all (97%) out of the 117 implants were grafted and were not subsequently lost due to additional loading.

Bone deficits in patients with partial or total adenitis may vary between 25% and 70%. This considerably reduces the possibility of attachment of removable prostheses and leads to negative attitudes towards removable prostheses in the future.[24,32] The use of piezosurgical techniques, on the other hand, has enabled the use of the bone resource of local origin. In this respect, the volume of utilization of foreign bone compounds for the body is either absent or minimal. Therefore, the auto-immune responses of the organism can also be avoided. Thus, the use of piezoesurgical methods is clearly justified, primarily because of their low trauma, antibacterial effect and quicker recovery period.

Conclusions

This research has established that the use of piezoelectric systems is more efficient than standard osteotomy techniques. Firstly, a smoother effect of the piezosurgical device on the edges of the wound was recorded, which subsequently creates an opportunity for a faster recovery. Besides, selective tissue dissection becomes possible, thereby minimizing the risk of damage to soft tissues such as the Schneider membrane and the mandibular nerve. This also contributes to an accelerated recovery period. The use of piezoesurgical techniques has been shown to reduce the likelihood of complications by a factor of four in comparison with the group of patients who have been treated with standard osteotomy techniques. Furthermore, the duration of the post-surgical rehabilitation period was 20% shorter. Analysis of reoparodontograms showed that in the second group of patients (piezoesurgical method), a vasoconstriction of regional vessels was observed which was eliminated one month after surgery. Microcirculatory indices corresponding to the standard were recorded one to two months after the transaction. In Group 1 (standard osteotomy techniques), a reduction in microcirculation indexes was noted. This points to stagnant processes in the microcirculatory channel. Thus, the piezosurgical method has shown advantages at all levels - from rehabilitation time to microcirculatory blood indices. Conducting control and selection of means for local anesthesia have helped to increase the safety and quality of local anesthesia.

Declaration of Interest

The authors report no conflict of interest.

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