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Influence Of Implant Drills Wear On The Heat Generated During The Osteotomy.LiteratureReview.

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Abstract:*Objective: Identify, if there is any evidence in literature of a detrimental increase in temperature when a deterioration and wear in implant drills occur. The Pubmed database was employed for this purpose.Results: Out of the 13 studies selected, all of them used an infrared camera as a temperature measurement method, since this is the most sensitive method defined. The highest temperature reported in the studies was 67.2ºC and the lowest was 24.1ºC. After 50 uses, a significant wear of the drill can be noticed. Even though this does not significantly affect the increase in temperature during drilling. This increment was more affected by factors such as: the diameter of the drill, the drilling sequence or irrigation.Conclusion: It seems to be that the wear of the drills does not significantly influence a temperature rise above 47ºC.*

Key words:*Implant drill; wear; heat; infrared.*

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I. Introduction

No matter how careful and minimally invasive the implant placement technique is, it is inevitable that a necrotic area appears around the created implant side, being this area proportional to the heat generated during drilling [1].It has been determined that a temperature of 47ºC during one minute creates a damage in the bone metabolism that prevents a later normal bone regeneration leading to a lack of osseointegration by the implant [2].Repeated use of the drills leads to wear, which reduces their efficiency and therefore, the friction temperature increases during drilling [3]. In addition to wear, the temperature increase is also influenced by other factors such as: the drilling speed, the cortical thickness, the drilling force, the drilling depth, the drill design, the drill diameter, the diameter increase between onedrill and another and irrigation [4].

Nowadays, there is still no clear evidence on the link between the number of times the drill can be used repeatedly and the number of sterilization cycles which can withstand before it becomes blunt and ineffective, producing a significant increase in temperature [5].Since the sharpness of the drill is one of the most important factors in terms of temperature increase, in order to minimize this surgical trauma, well sharpened drills are recommended [6].

The aim of this study is to review the current literature to analyze if there is any evidence of the number of uses that can support an implant drill before it loses its cutting ability and produces a detrimental increase in temperature.

II. Material And methods

In this literature review, a Pubmed database (MEDLINE) was used. Experimental studies from December 2008 to December 2018 were included, using keywords: *implant drills, wear, heat* and *infrared.*

III. ResultsAndDiscussion

Thirteen experimental studies were finally included in the review. Although the method used in the studies varies from study to study and taking into account that the wear of the drill is not the only element that affects the temperature rise during drilling, the following will be evaluated: the method used to measure the temperature rise, the type of bone model, the number of uses of each drill, the drilling sequence, the diameter of the drill, irrigation, the speed and axial force applied, as well as the length of the drill. (Table 1)

Table 1. Results of studies included in the review.

Study (author and year)	Measurement method	Bonemodel	No. of uses	Drill diameter(mm)	Irrigation	Speed (rpm)	Axial load (kg)	Drillinglength(mm)
***Frösch et al*2018**	Infrared camera	Polyurethanefoam blocks	10	2.2 2.8 3.5 4.2	Distilled water (25ºC). 40 ml/min	800 600 500 400	2.4 simple 0.6 sequential	12
***Lajolo et al*2018**	Infrared camera	Porcine rib	12	2	External irrigation. 50 m/min. Saline solution (NaCl 0.9%). Room temp.	1100	1 1,5	10
***Oh et al*2017**	Infrared camera	Polyurethanefoam blocks	20	3.6	25ªCsolution	1500	4±1N	15
***Moöhlhenrich et al*2016**	Infrared camera	Polyurethanefoam blocks	8	2.8 3.5 4.2	External irrigation. 50 ml/min (21±1ºC)	1500	-	12
***Boa et al*2015**	Infrared camera	Bovinerib	48	2 2.5 3 3.5	External syringe 50ml at 25ºC	800	-	-
***Lucchiari et al*2016**	Infrared camera	Bovinerib	20	1.9 2.2 2.8 3.5	Salineirrigation. Roomtemp.	800 800 600 500	40 Ncm	13
***Marković et al*2016**	Infrared camera	Bovinerib	24	2.35	Saline solution irrigation. 50 ml/min. (25ºC and 5ºC)	600	-	13
***Pires et al*2012**	Infrared camera	Porcine rib	80	2	Externalirrigation. Saline solution 0,9%	800		10
***Kim et al*2010**	Infrared camera	Porcine rib	10	2 3	No	1200 50	10	-
***Oh et al*2011**	Infrared camera	Polyurethanefoam blocks	20	3.1 3.25 3.45 3.6	No	1500	4N	15
***Scarano et al*2011**	Infrared camera	Bovinerib	18	3.7	Externalirrigation. Saline solution 0.9%	800	-	-
***Benignton et al* 2012**	Infrared camera	Bovinemandible	12 6	2 3.25	External and internal irrigation. Saline solution 0,9%	2500		-
***Bulloch et al*2012**	Infrared camera	Bovinefemur	90	3.5 4.2	Externalirrigation. Water	2100	2	-

3.1 Temperature measurement:

In the 13 studies comprised, an infrared thermography method is used [8,13-32],which allows an indirect measurement of temperature changes that occur during cavity milling. Despite another method is described in the current literature, whose measurement is direct, using thermocouples, in this review the studies that employ this method were not selected.They seem to be less precise, due to the fact that the studies on its usage are still not consistent. Further, there are variations in the distance from the sensor to the ploughed site (between 0.5 and 2 mm) which can produce variations in the temperature measurement [7,8].

3.2 Type of bone model:

There is no standard study model for implant site preparation research. The bone models used in the studies are divided into cadaveric animal bone models [8,13,14,16,17,20-23]and synthetic bone models [15,18,19,24].Among the animal models we find bovine ribs [8,14,22,23], porcine ribs [13,16,17], bovine mandible [21]and bovine femur [20].On the one hand, the bovine and porcine bone models, according to the classification of *Lekholm and Zarb*, would be encompassed within a type D3-D4 [9] bone.As they have a large amount of cancellousbone, they offer less resistance to drilling, so their results should be questioned. On the other hand, synthetic bones, made of polyurethane, can have a bone quality that goes from D1 to D4, so they offer much more reproducibility and results less sensitive to error, so they would be the best model to get a clear evidence [24].

3.3Number of uses:

The maximum number of uses an implant drill has until there is a wear that can be harmful, is still unknown.In the chosen studies, the uses vary enormously.In some of them, we observe they are used 6 times while in others they are used 90 times.The best described method to observe wear is the application of a scanning electron microscope [10-13], where it has been detected that even new drills have small microdefects.[13]This takes place from the 50th usewhena significant degradation and corrosion is noticed, although this does not significantly raise the temperature during drilling [11,12].Only in two of the studies, *Frösch et al.* and *Moöhlhenrich et al.,* the critical temperature of 47ºC is reached, which is not caused by the wear of the drill [19,24].

3.4 Drilling sequence:

The implant site can be drilled with a single drill or with a sequential drill to reach the desired diameter. It has been observed that the temperature increase is statistically higher in the single drill protocol compared to the sequential drill protocol.However, this data is clinically irrelevant. Therefore, the single drill protocol could be used without reaching a critical temperature that prevents osseointegration, in addition to reducing the time of the intervention. At the same time, in case of using guided surgery, the osteotomy would imply greater precision as it would not need to use reducers in the surgical splint. But in case of willing to change the axis of the implant it would not be possible, which would not happen with sequential drilling instead [14,19,20,24].

3.5Drill diameter:

In two of the studies, *Frösch et al.* and *Boa et al.,*where different diameters of drills are used, it is observed that the increase in temperature is inversely proportional to the diameter of the drill [19,22].According to *Frösch et al.* there would be an average temperature increase for the drill of 2.2mm at 5ºC, 33ºC and 16.3ºC in the coronal, medium and apical third, respectively, and of 4.9ºC, 15.6ºC and 14.2ºC, in the same thirds for the drill of 4.2mm [19].According to *Boa et al.* the temperature increase for the 2mm drill would be 4.7ºC and for the 3mm drill would be 3.32ºC [22].

3.6 Irrigation:

Many irrigation protocols are described in the literature, from internal to external or combined irrigation, varying the amount of irrigant per minute or even cooling the irrigant. *Benington et al.* investigated the heat generated using an external and internal irrigation system. They found a difference of approximately 0.1ºC for 2 mm drills and approximately 0.28ºC for 3.25mm drills. They concluded that the clinical benefit of using the more expensive internal irrigation system could not be justified [21].On the other hand, *Marković et al.* observed that when using external irrigation refrigerated at 5ºC, the temperature decreased significantly in both the coronal, middle and apical third of the implant site, using and without using surgical guidance. Thus,observing a maximum temperature increase of 3.54ºC in the apical third when using refrigerated irrigation and a maximum increase of 7.48ºC when using irrigation at room temperature. Therefore, the use of refrigerated irrigation is justified in order to reduce the temperature increase during cavity preparation [23].

3.7 Speed and axial force:

The revolutions per minute used in the studies range from 50 [16] to 2500 [21], being the usual no more than 1000rpm. In the study of *Kim et al.* the use of 50rpm is compared to 1200rpm obtaining that the lowest and highest temperature increases for 1200rpm were 1.57ºC and 2.46ºC and for 50rpm of 1.67ºC and 1.72ºC.They concluded that the difference was not significant enough and that the bone did not overheat more when using lower rpm than the usual [16].

Regarding the axial load, *Lajolo et al.* in their study compared the temperature changes produced by applying 1kg and 1.5kg of axial load in a conventional drilling system and in a piezoelectric drilling system. Theyobserveda maximum temperature increase (ΔT) in conventional drilling of 0.2ºC at low load;0.7ºCat high load; and a maximum temperature increase of 14.8ºC and 15.5ºC at low and high pressure loads, respectively, when using piezoelectric drilling. They concluded that the temperature increase is not affected by neither of the two pressure loads applied with conventional milling or with the piezoelectric device [17].

3.8 Length of implant site:

Two of the 13 studies measure the temperature in different parts of the implant side.*Frösch et al.* found that the maximum temperature reached during drilling was in the middle third (67.2ºC), followed by the coronal third (50.5ºC) and finally the apical third (46.3ºC) [19]. On the other hand, *Marković et al.* observed that the greatest temperature increase was in the coronal third (1.24ºC), followed by the middle third (1.10ºC) and finally the apical third (0.92ºC) [23].This discrepancy may be due to the fact that *Frösch et al.* in their study made 7 measurements on the length of the implant side, while *Marković et al.* made only 3 and the design of the drill used by the two of them, spiral drill [23] and pilot drill [19].

IV. Conclusion

Considering thateven new drills have micro-defects, it seems that there is no degradation until the 50th use which may significantly affect the cutting capacity of the drill. However, this eventdoes not cause an increase in temperature above 47 º C. More randomized clinical trialsmust be performed in order to deduce with certainty this evidence.

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