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CLINICAL PRACTICE ARTICLE

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Is it necessary to calibrate the rotational speed of the centrifuge?

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ABSTRACT

Centrifuge has become a commonly used device in medical and dental clinics, especially for preparing platelet-rich plasma and platelet-rich fibrin. The preparation protocol depends on the centrifugal force generated by the centrifugation process, which is directly affected by the rotational speed of the centrifuge. Therefore, any less accuracy in the real rotational speed results in a change in the centrifugal force that can affect the properties of the resulting material. For this reason, this study aims to ascertain whether the selected rotational speed of the centrifuge can be relied upon as an actual speed and can be used in the calculation of the centrifugal force. Fifteen new centrifuges from different origins were randomly selected. Each centrifuge was set at a specified speed. Then, two tubes were placed inside each one. A thin, flexible piece of plastic was placed touching the cap of the tubes during their rotation to make a sound. Following that, the sound was recorded with a special recording device. Subsequently, the 15 recorded audio files were analyzed using a software application. Finally, the number of waves per minute was counted, and the rotational speed was calculated. It was found that 10 of 15 devices showed significant differences between the selected speed and the actual speed. Moreover, the percentage difference for these 10 centrifuges ranged from 15% to 43%. In conclusion, it is recommended to pre-assess and calibrate the centrifugal speed in the beginning, to obtain the required centrifugal force.

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Introduction

Centrifugation is a process that separates particles in a fluid medium using centrifugal forces. During the rotational movement, a centrifugal force is developed on the suspended particles. The amount of force is directly proportional to the diameter and the rotational speed, according to the following equation:

$$CF = 1.118 \times r \times \left(\frac{RPM}{1{,}000}\right)^2 \quad (1)$$

CF: Centrifugal force (units of gravity g = 9.80665 m/s^2)
r: Radius (mm)
RPM: Revolutions per minute

A centrifuge has been a commonly used instrument in regenerative medicine, laboratory diagnostics, and molecular biology. It is used to extract particles of different densities from various mediums using centrifugal forces. Its primary uses include separating plasma from whole blood for preparing platelet-rich fibrin or platelet-rich plasma, which plays an important role in periodontal surgery [1], bone regenerative procedures [2], and many aesthetic treatments [3–7]. Centrifuge is also used in immunoassays or hematocrit analysis [8], separating pathogens and parasites in biological fluids [9], and preparing DNA extraction steps [10]. Moreover, each one of these procedures has its unique centrifugation protocol, that depends on the centrifugal forces [11]. Therefore, any change in the centrifugal

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force can directly affect the quality of the resulting biomaterial [12].

Through this evolution, hundreds of centrifuges have appeared in the market which makes the selection process even more difficult [13]. The most important factors that control the centrifugation process are the duration and the centrifugal force [13]. The first factor (duration) can be adjusted easily, but the second one (centrifugal force) requires calculations by applying a specific equation (*Eq. 1*), which is affected by the rotational speed set on the device.

The aim of the study is to examine the actual rotational speed and compare it with the centrifuge's selected speed, to ascertain whether the selected speed can be relied upon as a real speed and use it in the calculation of the centrifugal force.

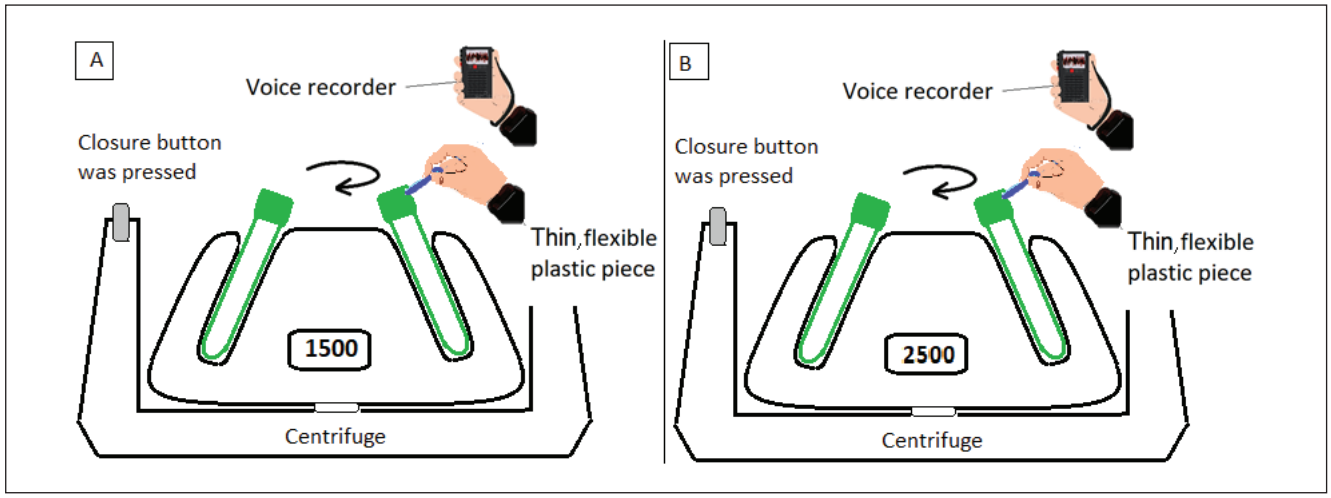

Figure 1. Method of speed assessment: (A) Experiment 1: 1,500 rpm, (B) Experiment 2: 2,500 rpm.

Figure 2. Placement of a thin plastic piece touching the cap of the tubes during their rotation.

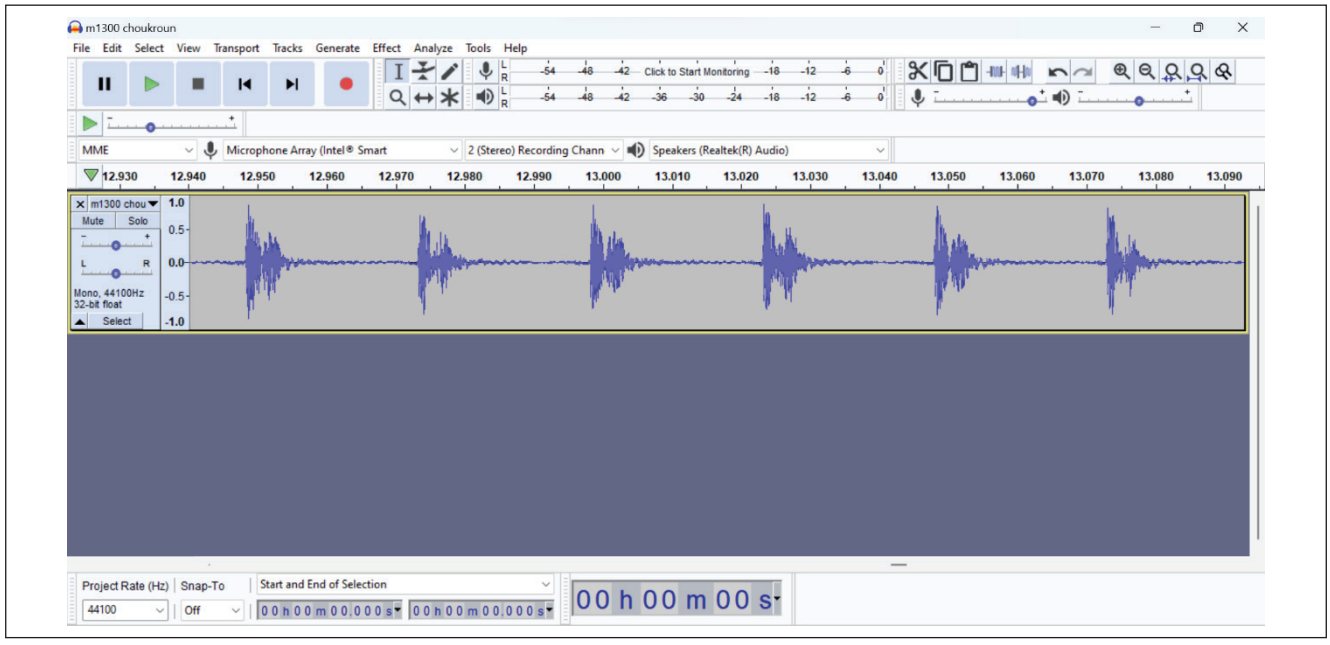

Figure 3. Audio analysis using Audacity®.

Materials and Methods

Fifteen new centrifuges from different origins and prices were randomly collected, numbered, and examined. *Each one of them was examined at two different rotational speeds (1,500 and 2,500 rpm) as described below.*

Two tubes filled with water were placed in a balanced position inside the centrifuge. A thin (0.1 mm), flexible piece of plastic was placed touching the cap of the tubes during their rotation. The speed of the centrifuges was set at 1,500 rpm. The plastic piece started to make a sound during rotor movement *(Figs. 1 and 2).* The sound was recorded using a specific recording device (Sony UX560®) between the first and second minutes of rotation to ensure a constant speed. After transferring the audio file to the computer, the sound waves were analyzed using a software application (Audacity®). *(Fig. 3)* The number of waves was counted for 3 seconds. This number was multiplied by 20 to get the number of rotations in a minute. Because two tubes were presented, the actual rotational speed is half of the resulting number, as the sound was recorded twice in a single rotation.

The previously mentioned steps of this procedure were repeated at a speed of 2,500 rpm. The results were also recorded and analyzed as well. Finally, the percentage difference was calculated (Eq. 2).

$$\text{Percentage difference} = 100 \times |a - b| / ((a + b) / 2) \quad (2)$$

a: the actual rotational speed per minute.
b: the selected rotational speed.

Results

Only 5 of the 15 devices showed relatively identical results between the selected speed and the actual speed as summarized in Table 1. However, the other ten devices showed a significant difference between the selected and actual speed. The percentage difference ranged from 15% to 43% (Table 1).

Discussion

In this study, we examined the accuracy of the selected speed of the centrifuge. The results were remarkable, as most of the examined centrifuges showed a mismatch between the actual speed and the set speed, which directly affects the centrifugal force and the properties of the resulting material after the centrifugation, as reported in many previous studies [12,14,15]. Centrifugal force is determined according to the required procedure, whether it is platelet-rich plasma, platelet-rich fibrin, or laboratory tests. Therefore, the rotational speed should be assessed as done in our study, and then calibrated according to the required centrifugal force after measuring the rotor radius (Eq. 1).

In our study, we examined the centrifuges at two different speeds to ensure the accuracy of the results. In addition, new centrifuges were randomly selected to reduce the risk of bias that can result

Table 1. Comparison between the selected and the actual rotational speed.

	Selected rotational speed (rpm)	Actual rotational speed (rpm)	Percentage difference
Centrifuge 1	1,500	1,490	0.7%
	2,500	2,493	0.3%
Centrifuge 2	1,500	2,150	43%
	2,500	3,450	38%
Centrifuge 3	1,500	1,950	30%
	2,500	3,075	23%
Centrifuge 4	1,500	1,514	0.9%
	2,500	2,521	0.8%
Centrifuge 5	1,500	1,923	28%
	2,500	3,098	24%
Centrifuge 6	1,500	1,735	16%
	2,500	2,870	15%
Centrifuge 7	1,500	1,492	0.5%
	2,500	2,490	0.4%
Centrifuge 8	1,500	2,100	40%
	2,500	3,450	38%
Centrifuge 9	1,500	1,875	25%
	2,500	3,050	22%
Centrifuge 10	1,500	1,489	0.7%
	2,500	2,488	0.5%
Centrifuge 11	1,500	2,130	42%
	2,500	3,325	33%
Centrifuge 12	1,500	2,010	34%
	2,500	3,200	28%
Centrifuge 13	1,500	1,505	0.3%
	2,500	2,502	0.3%
Centrifuge 14	1,500	1,890	26%
	2,500	3,025	21%
Centrifuge 15	1,500	1,800	20%
	2,500	2,950	18%

from the frequent usage of devices. The plastic piece that was used was very thin and flexible, so it did not direct any frictional forces. Moreover, the significant differences between the examined centrifuges in this experiment prove that there was a mismatch between the actual speed and the set speed.

One of the main limitations of this study is the failure to evaluate the accuracy of the rotational speed following a certain period of utilization, which indicates the need for periodic device assessment and calibration.

Conclusion

The selected rotational speed of the centrifuge may not match the actual rotational speed. Therefore, it should be pre-assessed and calibrated to obtain the required centrifugal force. The use of sound wave analysis applications could help in measuring the rotational speed.

Acknowledgment

Not applicable.

Conflict of interest

The authors have nothing to disclose.

References

1. Pullishery F, Alattas M, Abdelrasoul M, Hashir H. Effectiveness of i-PRF in periodontal regeneration—a systematic review and meta-analysis. Saudi Dent J 2024; 36:214–21.
2. Lahham C, Ta'a M, Lahham E, Michael S, Zarif W. The effect of recurrent application of concentrated platelet-rich fibrin inside the extraction socket on the hard and soft tissues. A randomized controlled trial. BMC Oral Health 2023; 23:677–82.
3. Mijiritsky E, Assaf H, Peleg O, Shacham M, Cerroni L, Mangani L. Use of PRP, PRF and CGF in periodontal regeneration and facial rejuvenation-a narrative review. Biology (Basel) 2021; 12:103–9.
4. Miron RJ, Fujioka-Kobayashi M, Choukroun J. Platelet-rich fibrin and soft tissue wound healing: a systematic review. Tissue Eng—Part B: Rev 2017; 14:98–109.
5. Dashore S, Chouhan K, Nanda S, Sharma A. Platelet-rich fibrin, preparation and use in dermatology. Indian Dermatol Online J 2021; 12:72–9.
6. Parween S, George J, Prabhuji M. Treatment of multiple mandibular gingival recession defects using MCAT technique and SCTG with and without rhP-DGF-BB: a randomized controlled clinical trial. Int J Periodontics Restorative Dent 2020; 23:43–8.
7. Oswal P, Kour P. Free gingival graft along with I-Prf for recession coverage and interdental papilla augmentation: case report. IOSR J Dent Med Sci 2020; 19:66–72.
8. Sule SS, Petsiuk AL, Pearce JM. Open source completely 3-D printable centrifuge. Instruments 2019; 3:2–9.
9. Pitt WG. Rapid separation of bacteria from blood-review and outlook. Biotechnol Prog 2016; 32:823–39.
10. Lee H, Na W, Park C, Park KH, Shin S. Centrifugation-free extraction of circulating nucleic acids using immiscible liquid under vacuum pressure. Sci Rep 2018; 8:34–8.
11. Miron RJ, Xu H, Chai J, Wang J, Zheng S, Feng M. Comparison of platelet-rich fibrin (PRF) produced using 3 commercially available centrifuges at both high (~ 700 g) and low (~ 200 g) relative centrifugation forces. Clin Oral Investig 2020; 24:134–8.
12. Castro A, Andrade C, Li X, Pinto N, Teughels W, Quirynen M. Impact of g force and timing on the

characteristics of platelet-rich fibrin matrices. Sci Rep 2021; 11:51–60.

13. Dohan D, Pinto N, Pereda A, Jiménez P, Corso M, Quirynen M. The impact of the centrifuge characteristics and centrifugation protocols on the cells, growth factors, and fibrin architecture of a leukocyte- and platelet-rich fibrin (L-PRF) clot and membrane. Platelets 2018; 29:2–7.
14. Feng M, Wei Y, Wei H, Wang Y, Zhang Y, Miron RJ. Effect of relative centrifugal force on the biological properties of liquid platelet-rich fibrin produced via horizontal centrifugation. Clin Oral Investig 2023; 27:1–4.
15. Miron RJ, Pinto NR, Quirynen M, Ghanaati S. Standardization of relative centrifugal forces in studies related to platelet-rich fibrin. J Periodontol 2019; 90:88–93.