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# Antimicrobial effects of various platelet rich concentrates-vibes from in-vitro studies-a systematic review

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ABSTRACT

*Aim:* The aim of the current review was to outline the existing information related to antimicrobial properties of various platelet concentrates, as experimented in various in-vitro studies.
*Background:* One of the most interesting recent landmarks in the field of biological therapy has been the discovery that platelets, in addition to being capable of releasing hundreds of proteins and growth factors, can also release immunomodulatory agents with antimicrobial activity. Several international research groups have reported antimicrobial activities in both human platelets and other types of platelet rich plasma preparations.
*Review Result:* This review was carried-out pursuing a systematic approach. An electronic search was conducted on MEDLINE and GOOGLE SCHOLAR databases using suitable search terminologies. It included preclinical studies which assessed the antimicrobial activity of Autologous Platelet Concentrates(APC).Ten in-vitro studies and one animal study, which investigated APC effects on various microorganisms, were included. Almost in all the included in-vitro studies, it was found that complete breakdown of microbial load could not be achieved by any of the APC preparations but there occurred a reduction in the growth of microorganisms. Thus APCs displayed a bacteriostatic rather than bacteriocidal activity.The only animal study included in this review which had both in-vitro and in-vivo evaluation, also showed reduction of infection caused by different microorganisms.
*Conclusion:* Although the precise mechanism of synergy with microbial pathogens needs further validation, platelet concentrates proved to have antimicrobial properties.

## 1. Introduction

Platelets perform a pivotal role in hemostasis and wound healing and growth factors released by them are well recognised reservoir of healing cytokines.[1]

Platelets measure about 2–3 μm in diameter and are anucleate cytoplasmic fragments which are basically derived from bone marrow megakaryocytes.[2] They enclose within themselves many granules, few mitochondria and 2 prominent membrane structures, the surface-connected canalicular system and the dense tubular system.[1] Amongst all those granules present in platelets, the α granules which are considered to be intracellular storage pool of proteins vital for wound healing, are spherical or oval structures with diameters ranging from 200 to 500 nm each enclosed by a unit membrane.[3] These proteins include platelet-derived growth factor (PDGF), transforming growth factor (TGF-β), and insulin-like growth factor (IGF-I).[4] On activation, these granules fuse with the platelet cell membrane and as a result at least some secretory proteins are transformed into a bio-active state. Transformation of these proteins into bioactive state allows them to bind to trans membrane receptors of the target cells.[5] The process of binding to target cells leads to generation of intracellular signal proteins. Thus resulting in gene sequence expression that directs cellular proliferation, collagen synthesis, osteoid production, and so on.[1]

This concept has led many researchers to invent various types of platelet concentrates (PCs) eg PRP (Platelet Rich Plasma), PRGF (Plasma Rich In Growth Factors), PRF (Platelet Rich Fibrin) etc. The current consensus gives us a simple classification system dividing these products in 4 main families, based on their fibrin architecture and cell content.[3]

- Pure Platelet-Rich Plasma (P-PRP),[3] such as Emcyte
- Leukocyte- and Platelet-Rich Plasma (L-PRP) [3]
- Pure Platelet-Rich Fibrin (P-PRF) [3]
- Leukocyte- and Platelet-Rich Fibrin (L-PRF)[3] or Choukroun's PRF

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These 4 main categories of products offer different biological signatures and mechanisms, and obvious differences in clinical applications. This classification forms the basis for further investigations of their role and effects.

Ghanaati et al. introduced the "low-speed concept" for blood centrifugation whereby lower centrifugation speeds were shown to contain higher numbers of cells including leukocytes before the formation of a fibrin clot.[6]

Joseph Choukroun further classified PRF preparations based on low centrifugation speed[7–10] like.

- A-PRF (Advanced PRF) – 1300 rpm/14 min
  - •A-PRF+ (Advanced PRF+) - 1300 rpm/8 min
  - •i-PRF (Injectable PRF) – 700 rpm/3min
  - •i-PRF M [Injectable PRF(Male)] – 700 rpm/4 min
  - •i-PRF+ (Injectable PRF+) – 700 rpm/5min
  - •A-PRF (L) – A-PRF(LIQUID) −1300 rpm/5 min

The above mentioned autologous platelet preparations are all different entities since one has to follow specified or prescribed protocol for their preparation. Their exists three variables in preparation of these APCs i.e RCF (Relative Centrifugation Force), Centrifugation time and Centrifugation Speed. Now according to Joseph Choukroun & S.Ghanaati, lowering either one or all the three variables leads to generation of PC which is higher in platelet, leucocytes and growth factor concentration.[8,9]

While the regenerative potential of platelet concentrates has been extensively explored since their introduction in regenerative medicine in the oral and maxillofacial surgery field during the late 1990s,[11,12] only few studies have investigated their antimicrobial effect, although an increase of publications in this field of research occurred in recent years.

The mechanisms underlying the antimicrobial effect of platelet concentrates are not yet clear. Platelet concentrates consist of a complex mixture of variable concentrations of platelets and plasma and, depending upon the protocol used for their production, variable content of leukocytes, embedded in a more or less dense fibrin matrix.[13,14] Nevertheless, the respective impact and mechanism of action of each component, as well as possible synergistic effects among these components, in the fight against infection are still poorly known.

## 2. Aim

To evaluate and compare the antimicrobial activity of various Autologous Platelet Concentrate (APC) preparations and to shed light upon their possible underlying mechanism and potential benefits.

## 3. Method

### 3.1. Literature search

A systematic search was performed using the following search terms, alone and in combination, by means of Boolean operators: "platelet-rich plasma," "PRP", "platelet concentrate," "platelet rich fibrin," "PRF", "plasma rich in growth factors," "PRGF", "microorganisms," "antibacterial," "antimicrobial" and "infection and searched two electronic databases, namely, Pubmed/MEDLINE, and Google Scholar from January 1970 up to January 31, 2018.

We searched for only In-vitro studies. Additional studies were retrieved through hand search of the references from relevant articles and manual search of journals. Authors independently reviewed all the retrieved titles, and abstracts were screened where title was unclear. The abstracts thus found relevant were selected for full text reading. The articles selected for full text reading were read and evaluated by the individual reviewer independently for assessing and retrieving the information relevant for the review.

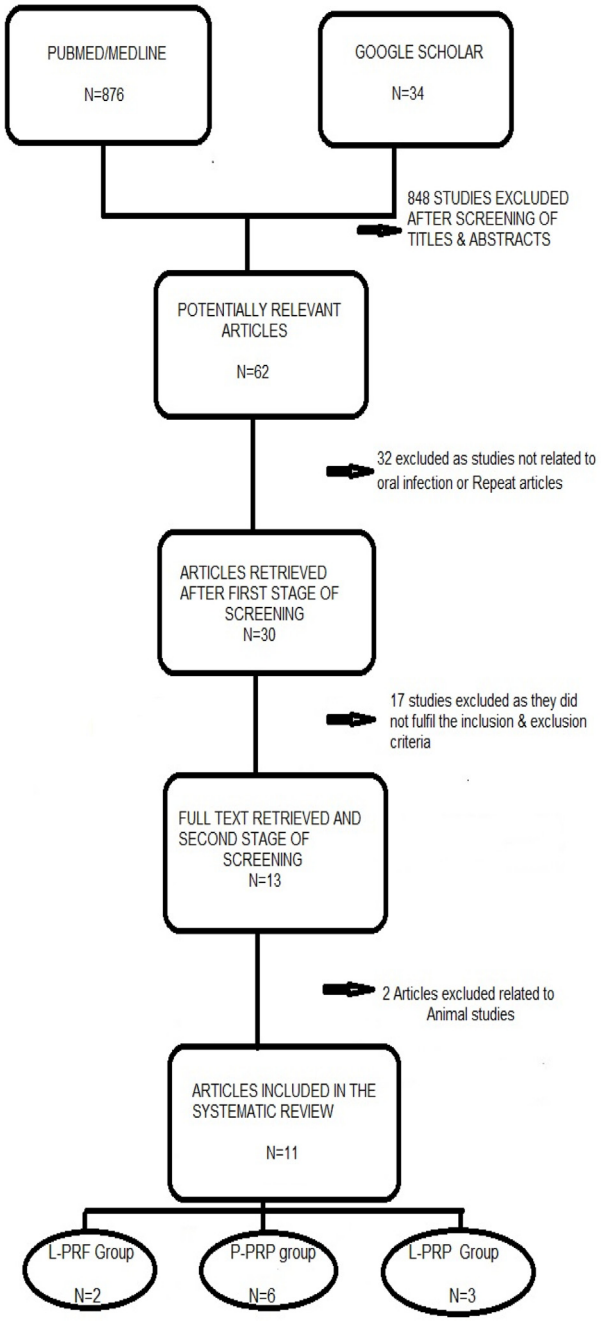


**Fig. 1.** Flow diagram.

### 3.2. Inclusion and exclusion criteria

Only in-vitro studies assessing the antimicrobial activity of platelet concentrates prepared from human volunteers were included. All other types of study design including animal studies and studies not evaluating microorganisms of oral infection were excluded.

### 3.3. Data extraction

The titles and abstracts of the retrieved articles were independently screened by two reviewers and potentially relevant articles were identified initially. In the first stage of screening, repeat articles and studies which did not address the issue of oral infection were excluded. Full text were obtained and examined, when the title and abstract of an article did not provide sufficient information to make a decision.

Publications were excluded if they did not meet the inclusion criteria. The full text of the included studies was obtained for data extraction. The attributes of the selected studies were examined and the articles were categorised into three groups: (a) L-PRF group (b) P-PRP group(c) L-PRP group. (Fig. 1).

## 4. Results

The initial electronic search provided 910 articles. Fig. 1 is a flow diagram that summarizes the article selection process. After screening of the titles and abstracts, 848 articles were excluded and only 62 studies evaluating the antimicrobial effect of Platelet Concentrates were identified. No further study was identified by other search methods. Around 32 articles were either not related to oral infection or were repeat studies. Thus they were excluded from the review. Out of the 30 studies included in the first stage of screening only 13 studies meet the inclusion and the exclusion criteria. After review of the full text, 2 publications were excluded for the following reasons.

Both these studies were animal model studies involving use of animal blood and the protocol used for the preparation of PCs were also slightly different from that was used in other in-vitro studies.

Thus over all 11 studies were included and these were again divided into three different groups, depending upon the protocol used for PC preparation i.e L-PRF group (2 studies), P-PRP group (6 studies) and L-PRP group(3 studies).

### 4.1. In-vitro studies

In the L-PRF group, 2 in-vitro studies[15,16] (Table 1) were included. These studies prepared PRF following Choukroun et al. protocol as described in the year 2000.Thus PRF prepared was rich in leucocytes. This L-PRF was compared with other platelet rich concentrates like PRP, iPRF and whole blood. Microorganisms tested were P.gingivalis, A.Actinomycecomitants in one study whereas in the other, microorganisms present in supragingival plaque samples were evaluated. These microorganisms were grown anerobically on culture plates and the amount of zone of inhibition created was measured to test the antibacterial efficacy. Results of these studies showed considerable variation. In one study[15] L- PRF showed no antibacterial activity as compared to PRP whereas in the other,[16] PRF and i-PRF showed significant antimicrobial activity compared to PRP and whole blood.

In P-PRP group six in-vitro studies (Table 2) were found to be satisfactory for inclusion in this systematic review.

In the First study[17] PRGF (Plasma Rich In Growth Factors) was investigated for its antibacterial properties. Use of PRGF preparation was first advocated by E. Anitua and is considered to be pure plasma preparation without the presence of leucocytes in it. Thus this preparation was designated under the category of pure platelet rich plasma i.e P-PRP. In this study[17] PRGF was prepared by taking venous blood sample from volunteers and was subjected to 580g of force for 8mins in centrifuge to obtain three consecutive fractions: fraction (F)1,F2 and F3. Later F2 fraction was discarded and F3 fraction was enriched with leucocytes. Main purpose of enriching this fraction with leucocytes was to see their role in antibacterial activity. Thus three Fractions namely F1, F3 and F3 + leu were tested against both methicillin-Sensitive (MSSA) and Resistant *Staphylococcus aureus* (MRSA) and Staphylococcus epidermidis(MSSE & MRSE) strains of bacteria. Antibacterial activity was tested using kill assay i.e by counting the number of the surviving bacterial colonies after incubation at 0, 4 and 8 h Result demostrated that all fractions remained bacteriostatic upto 4 h, for both methicillin-sensitive and resistant strains of bacteria but after 8 h some bacterial regrowth was observed. When antibacterial activity was compared, F3 + leu was found to be significantly superior to that of F3 ($P < 0.05$) but not to that of F1 fraction for MRSA strain. Whereas for MSSA strain, no significant difference in antibacterial activity was found between the various fractions.

**Table 1**
L-PRF group.

| Author, year | Platelet concentrate | Micro-Organisms tested | Result | Conclusion |
|---|---|---|---|---|
| Badade et al.,[15]2016 (in-vitro) | PRF/PRP | P. gingivalis, A.actinomycetemcomitans. | P.gingivalis and A. actinomycetemcomitans were inhibited by PRP but not by PRF. | PRP is a potentially useful substance in the fight against periodontal pathogens. |
| Karde et al.,[16] 2015 (in-vitro) | iPRF/PRF/PRP/WHOLE BLOOD. | Microorganisms of supragingial plaque incubated aerobically on agar plates for 48 h. | Mean zone of inhibition (in cm) around i-PRF, PRF, and PRP were 1.42 ± 0.25, 1.3 ± 0.16, and 1.02 ± 0.12, respectively. | i-PRF has a significant inhibitory effect on growth of oral bacteria in comparison to other platelet concentrates. |

**Table 2**
P-PRP group.

| Author, year | Platelet concentrate | Micro-Organisms tested | Result | Conclusion |
|---|---|---|---|---|
| E.Anitua et al.,[17]2012 [in-vitro] | PRGF | Methicillin-sensitive and Methicillin resistant *Staphylococcus aureus*(MSSA & MRSA) and Staphylococcus epidermidis.(MSSE &MRSE). | All formulations had an antibacterial effect at 4 h for three of the four strains, with the exception of Methicillin-sensitive S.epidermidis(MSSE). | PRGF-Endoret could be used in the fight against postoperative and wound infections. |
| Lorenzo Drago et al. [18],2013 [in-vitro] | P-PRP | E.faecalis, C. albicans, S.agalactiae, S. oralis and *P. aeruginosa*. | P-PRP inhibited the growth of *E. faecalis*, C.albicans, S. agalactiae and S. oralis, but not of P.aeruginosa strains | P-PRP is a potentially useful substance in the fight against postoperative infections. |
| Li-Chiu Yang et al.[19], 2015 [in-vitro] | PRP and OTHER PLASMA PREPARATIONS | P.gingivalis, A. actinomycetemcomitans and F. nucleatum | All plasma preparations can inhibit bacterial growth, with PRP showing the superior activity | PRP expressed antibacterial properties, which may be attributed to platelets possessing additional antimicrobial molecules. |
| Lorenzo Drago et al.[20],2014, [in-vitro] | P-PRP/PPP | Ten different strains of *E. faecalis*, S. agalactiae, S. oralis and S.aureus, isolated from oral clinical samples. | Both P-PRP and PPP were able to inhibit the growth of *E. faecalis* and S.aureus strains. S.agalactiae and S.oralis strains seemed to be slightly more susceptible to P-PRP than PPP. | Antimicrobial activity of platelet concentrates against *E. faecalis*, S. agalactiae, S. oralis and S. aureus is sustained by a co-operation of plasma components and platelet-derived factors. |
| E.Mariani et al.[21],2014 [in-vitro] | P-PRP/PPP/control | *E. coli*, S aureus, K.pneumoniae, P aeruginosa and S faecalis. | Both preparations (P-PRP and PPP) produced a fair growth inhibition for at least up to 2 h of incubation. None of the strains were entirely inhibited, the number of bacteria increased with the time of incubation (4 h), reaching comparable growth among P-PRP, PPP and control conditions after 18 h of incubation, | As inhibitory activity is evident from the first hour of treatment,so PRP supplies an early protection against possible bacterial contaminations during minor or radical surgical interventions. |
| J. Intravia et al.[22] 2014 [in-vitro] | PRPLP (low platelet)/ PRPHP(high platelet) | S.aureus, S.epidermidis, MRSA or Propionibacterium acnes. | Both PRP products showed a significant decrease ($p < 0.05$) in bacterial growth at 8 h compared to whole blood. | Despite differences in platelet concentra - tion and WBC concentration, no difference in an- tibacterial activity was seen between the two preparations. |

Also in contrast to above findings, MSSE strain was found to be less susceptible than MRSE to various fractions of PRGF preparations. The bacterial population was reduced only by F3 + leu fraction for MSSE, whereas for MRSE strain, no significant difference was found between the various fractions.

In another study of this group,[18] P-PRP was used. Protocol used for its preparation was similar to that advocated by E. Anitua. Its antibacterial affect was evaluated against microorganisms of oral cavity namely *Enterococcus faecalis*, Candida albicans, Streptococcus agalactiae, Streptococcus oralis and *Pseudomonas aeruginosa* and was calculated by determining MIC (Minimum inhibitory concentration).Result showed that P-PRP was effective against all these microorganisms except *Pseudomonas aeruginosa* strain. Though it killed these microorganisms at a concentration 3-4 times the MIC.

Authors in this group of studies[17–19] used calcium chloride for activation of platelets. Moreover, in one study[20] a comparison was done between activated and non-activated P-PRP.

As regards to the study findings, in general it was observed that there was a tendency of platelet concentrates to inhibit the growth of microorganisms during the first hours of incubation, while they did not seem to be able to break down completely the microbial load: after an initial reduction of the inoculum, in fact, a recovery of bacterial growth was always observed, indicating that platelet concentrates displayed an inhibitory (bacteriostatic) rather than a microbicidal activity.[17,21,22] Concerning single bacterial species, S. aureus was the most tested microorganism and always showed susceptibility to platelet concentrates, while *Escherichia coli*, *Pseudomonas aeruginosa*, *Enterococcus faecalis* and *Klebsiella pneumoniae* were less frequently adopted and produced contradictory results: in some studies[18,20] antimicrobial activity was observed, but in other[21] no inhibitory effect against these species were obtained. In addition, some species were tested only once (e.g. Propionibacterium acnes, Fusobacterium nucleatum, etc.) for their antibacterial activity.

In L-PRP group, three studies (Table 3) were included. Out of that, two were in-vitro studies[23,24] and one study was an experimental study[25] in which both in-vitro and in-vivo evaluation was done. In this group the PC prepared was rich in Leucocytes and Platelets were activated using bovine thrombin.

Microorganisms tested in this group were S.aureus, E.coli, K.pneumoniae, E.faecalis and P.aeruginosa. Antibacterial activity was measured using Bacterial Kill assay or measuring the zone of inhibition on Agar plates. Antimicrobial activity was seen against all these microorganisms upto 6 and 24 h except for P.aeruginosa, E.faecalis & K.pneumoniae.[23,24]

The experimental Study[25] included in this group requires special mention as in this study PC was prepared using human volunteer's blood.Its antibacterial activity was first evaluated by in-vitro means and later it was applied in osteomyelitis induced Adult Rabbit models. In In-vitro analysis, antibacterial property of PLG (Platelet Leucocytic Gel) was compared with PRP, PPP (Platelet Poor Plasma) and PBS (Phosphate Buffered Saline) against S.Aureus. Result demonstrated bacteriostatic action which persisted for 2,4,6,8,12 & 24 h with respect to PLG & PRP. Also this difference was significant ($P < 0.05$) when compared to PPP and PBS.

## 5. Discussion

Role of various Autologous Platelet Concentrates (APC) in the regeneration of lost or damaged tissue have been investigated widely but there are very few studies which have investigated its antibacterial or antimicrobial potential on various microorganisms.

Following are the possible mechanisms hypothesized for platelet having antibacterial actions.

- Platelets act as senti-nels of the vascular system, express a wide range of potential bacterial receptors, may have the ability to

**Table 3**
L-PRP group.

| Author, year | Platelet concentrate | Micro-Organisms tested | Result | Conclusion |
|---|---|---|---|---|
| Dirk Jan F. Moojen et al.[23],2008 [in-vitro] | PLG-AT(Autologus thrombin), PLG-BT(Bovine thrombin), PRP and PPP | S. aureus | Cultures showed a rapid decrease in the number of bacteria for both PLG-AT and PLG-BT, which was maximal between 4 and 8 h. The effect of PLG-AT was largest and significantly different compared to PRP and PPP), however not compared to PLG-BT | Platelet-leukocyte gel, as an autologous blood product,has a strong bactericidal activity and thus might be a potentially useful substance in the fight against postoperative infections. |
| T.M. Bielecki et al.[24] 2007 [in-vitro] | Platelet-rich gel | MRSA, MSSA, *E. coli*,K.pneumonia, *Enterococcus faecalis* and P.aeruginosa | Platelet-rich gel inhibited the growth of S.aureus and was also active against E.coli. There was no activity against K.pneumoniae, E.faecalis, and P.aeruginosa. Moreover, platelet-rich gel seemed to induce the in vitro growth of P.aeruginosa, suggesting that it may cause an exacerbation of infections with this organism. | A combination of the Inductive and antimicrobial properties of platelet-rich gel can improve the treatment of infected delayed healing and nonunion |
| Jia.W et al.[25], 2010 [in-vitro & in-vivo] | Autologous PRP | *Staphylococcus aureus* | In vitro test showed that PLG had the most obvious bacteriostasis effect. The bacterial count reached a minimum value at 4 h after incubation in PLG and at 6 h after incubation in PRP. PPP had slow and no obvious bacteriostasis effect and PBS had no bacteriostasis effect At 2, 4, 6, 8, 12, and 24 h of incubation, the bacterial count reduced significantly when compared PLG with PRP and PPP ($P < 0.05$), when compared PRP with PPP ($P < 0.05$). | PRP forms into PLG after activating, it can inhibit S.aureus reproduction in vitro and can effectively prevent bone infection in vivo |

internalize bacteria and are able to release a broad variety of molecules that provide an array of host defence functions.[26]

- In vitro studies demonstrated that platelets, following stimulation with thrombin, are able to release proteins with antimicrobial activity against bacteria and fungi.[27,28]
- In addition to the release of antimicrobial peptides, platelets are also able to generate reactive oxygen species, bind and internalize microorganisms and participate in antibody-dependent cellular cytotoxicity.[29]
- Recent studies underlined the direct role of platelets in recognizing, sequestering and neutralizing invading pathogens, as well as their indirect contribution to recruiting leukocytes to infection and inflammation sites, and in modulating their behaviour, enhancing their ability to phagocytose and kill microorganisms by triggering different types of signalling pathways.[30]

The aim of this systematic review was to collect the available preclinical evidence, consisting of in vitro studies evaluating the antibacterial efficacy of APCs. The results of the various studies in literature suggest that platelet concentrates may be effective in inhibiting the growth of a wide variety of microorganisms. However, when considering specific bacterial species, results were sometimes contradictory. Such discrepancies could be due to several reasons such as the intrinsic characteristics of the bacterial strains used, which may display a different susceptibility to platelet concentrates per se or to the different sensitivity of the test used for assessing the antibacterial activity. Other important reasons for explaining the observed variability in outcomes could be ascribed to the types of platelet concentrates used that, may differ in form (gel or liquid), as well as in the concentration of platelets, content of leukocytes, density of the fibrin network, the activation mode that may occur naturally by contact with tissues or may be induced by thrombin or calcium chloride.

In order to overcome such discrepancies or variability in results and to draw a possible conclusion, in this review the selected studies were divided into three main groups namely L-PRF, P-PRP and L-PRP group (Fig. 1). The main aim of such categorization was to maintain standardization among each group with respect to protocol for the preparation of Platelet Concentrate, contents of leucocytes, concentration of platelets, density of fibrin and mode of activation. All studies were basically in-vitro studies[15–24] except one which was an animal study[25] and in that also only its in-vitro evaluation was considered in this review.

Basis of this categorization was the classification given by Dohan Ehrenfest et al.,[3] in which various platelet concentrates were classified into four main categories, depending on their leukocyte and fibrin content: P-PRP, L-PRP, pure platelet rich fibrin (P-PRF) and leukocyte- and platelet-rich fibrin (L-PRF).

So the first category was L- PRF, in which the PC prepared was basically leukocyte and platelet-rich fibrin (L-PRF).In this 2 in-vitro studies were selected[15,16] Antibacterial activity was determined by calculating the mean zone of inhibition caused by each PC. Studies showed contradictory results. In one of the study[15] L-PRF had no antibacterial activity while in the other[16] i-PRF and L-PRF showed significant antibacterial activity.

Second category was P-PRP group, in which the PC prepared was pure-platelet rich plasma. In this PC prepared was basically free of leucocytes and was activated with calcium chloride. In this category, six in-vitro studies[17–22] were included. Wide variety of microorganisms were tested for antibactierial activity namely S.aureus, S.epidermidis, P.aeruginosa, E.faecalis, S.oralis, S.agalactiae, C.albicans, F.nucleatum, P.gingivalis, A.actynomicetemcomitans, E.coli, K.pneumoniae etc. All these microorganisms falls under the category of oral and non-oral bacteria and have been implicated in oral conditions like endodontic and periodontal infections.[31] This PC showed antibacterial activity against all the microorganisms except P.aeruginosa. Even the growth of C.Albicans, which is a form of yeast, was inhibited. In the study

conducted by Mariani et al.[26] bacterial growth was inhibited only during early period of incubation i.e upto 2 h but later regrowth of bacteria was observed.

Various reasons were also cited to substantiate antibacterial activity of P-PRP in this group like platelets possessing additional antimicrobial molecules or presence of plasma components and platelet-derived factors.[20]

Plasma basically possesses complement system which is an element of the immune system essential for the mechanisms of humoral defense against infectious agents. The activation of the complement cascade determines bacterial cell lysis and leukocyte recruitment. Taken together, these data seem to suggest that some plasmatic components (such as the complement) are mainly responsible for the antimicrobial activity of platelet concentrates, and that a co-operation between platelets and plasmatic elements is necessary.[32]

The third category was L-PRP group, which consisted of three studies.[23–25] Out of three studies, 2 were in-vitro[23,24] and one was animal study.[25] In all these studies the L-PRP prepared had substantial amount of leucocytes in it and were activated by bovine thrombin.The microorganisms tested in this group were namely S.aureus, E.coli, K.pneumoniae, E.faecalis, P.aeruginosa. Results of in-vitro studies showed antibacterial activity against S.aureus and E.coli whereas no activity was seen with K.pneumoniae, E.faecalis and *P. aeruginosa*.

One of the purposes of this review was to observe the role of leucocytes on the antibacterial activity of APCs. Both L-PRP and L-PRF preparations contained substantial amounts of white blood cells. Looking into results obtained in studies of these two groups, Leucocytic rich preparations definitely have antibacterial activity but there were only few studies that compared platelet concentrates which were poor and rich in leukocytes[17,22] and both seem to suggest that there are no substantial differences between the antimicrobial activity of the two formulations. Thus it could be substantiated that White blood cells do possess a phagocytic activity and constitute a rich source of antimicrobial molecules (e.g. defensins, cathelicidins, lysozyme, myeloperoxidase). But it is difficult to understand how they can perform their function after they have been removed from the circulation for the preparation of platelet concentrates and applied directly to the surgical site, bypassing the physiological stage of migration.

Looking into the limitations of this review, point of standardization needs to be addressed. Main aim of the authors for grouping the APC into three main categories and then comparing the results was to overcome the variability in each study design.

But the variability persisted in terms of the microorganisms that were subjected to antimicrobial testing. Only limited number of microorganisms was tested in the various included studies. As a result, it becomes very difficult to identify the spectrum of each APC's activity.

## 6. Conclusion

In addition to the well-established regenerative properties, platelet concentrates seem to possess antimicrobial properties too. Thus this property of APCs could be utilized to treat oral in particular Gingival and Periodontal Infections.

Generally antibiotics in the form of Systemic or Local delivery systems are used as an adjunct to treat these infections but have the disadvantage of developing resistance. Thus these agents can overcome this disadvantage and provide an alternative means to various antibiotics used in our field.

Looking at these agents solely as an antimicrobial agent would limit its usage. Thus they should be viewed as an agent having both regenerative as well as antimicrobial effects.As a result they can be designated higher on the podium.

But before putting this stamp on it, antimicrobial spectrum of APCs has to be well established and its clinical effectiveness when used as an adjunct to mechanical form of therapy needs to be observed and investigated.

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## Conflicts of interest

Nil.

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