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Bone grafting with PRP and dental implantation for unilateral alveolar cleft patients

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ORIGINAL STUDY

Bone grafting with platelet-rich plasma and dental implantation for unilateral alveolar cleft patients

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Abstract

Background: **Cleft lip and palate deformity is the most common congenital craniofacial anomaly, often treated with alveolar bone grafting (ABG) in patients with alveolar clefts. Application of platelet-rich plasma (PRP) enhances healing by releasing high concentrations of cytokines from platelets. Over the past century, the treatment for alveolar clefts has evolved, with the current standard being autologous cancellous bone grafts from the iliac crest in 6−11-year-old patients during the mixed dentition period. The dental implant has a role of holding a dental prosthesis, preventing pronounced bone atrophy, and loading the augmentation material in the cleft area.**

Objectives: **The objective of this work is to evaluate the effectiveness of PRP injection with bone grafting and dental implantation in alveolar cleft patients.**

Patients and methods: **This study will be implemented on 30 patients from 15 to 20 years old from Qalyobia and Cairo governorates, including rural and urban areas.**

Results: **Regarding significant value, mobility was much higher in group 1 ($P = 0.001$). The time of loading was much shorter in group 1 ($P = 0.001$). The time of osteointegration was much higher in group 1 ($P = 0.001$). Sex, patient compliance, oral hygiene, infection, and failure of implant show nonsignificant differences. Complication and time of healing show the nonsignificant differences. The time of loading was recorded for group 1 (7.07 ± 1.10 min) and group 2 (10.13 ± 1.19 min). 27/30 of the patients were satisfied with the results.**

Conclusion: **Patient characteristics, infection rates, implant success, complications, and satisfaction were similar between groups. However, PRP injection led to a shorter time for implant loading and a longer time for osteointegration compared to the non-PRP group. Dental professionals should consider these timing differences when planning treatments, as they can influence outcomes and treatment timelines.**

Keywords: Bone grafting, Cleft lip palate, Dental implantation, Platelet-rich plasma

1. Introduction

Cleft lip and palate (CLP) is the most prevalent craniofacial congenital deformity [1]. With varying incidence by population, highest among Indians and Native Americans (three to four cases per 1000 births) [2], compared to one to two in Caucasians [3]. Females are more commonly present with isolated cleft palate, while males are more likely to have CLP [3]. CLP significantly affects facial growth and dental development, impacting esthetics, function, psychological well-being, and quality of life [4].

Alveolar bone grafting (ABG) is the main treatment for alveolar and palatal clefts, and mainly aimed at improving dental alignment. Allows for canine eruption or implant placement in the grafted area, enhancing dental alignment [5]. Using autologous blood products like platelet-rich plasma (PRP) in ABG accelerates healing by releasing high cytokine concentrations from platelet degranulation [6]. Surgeons have adopted PRP containing concentrated cytokines like platelet derived growth factor (PDGF), endothelial growth factor (EGF), vascular endothelial growth factor (VEGF), and

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transforming growth factor beta (TGF-β) in oromaxillofacial and musculoskeletal applications with PRP [7].

Alveolar clefts result from developmental disruptions in the frontonasal area. The common site for these clefts is between the lateral incisor and canine. Historical treatments have included autologous tissue grafts, nonvascular bone grafts, and tibial bone repairs [8]. The use of iliac bone grafts had been introduced by Skoog [9]. Previously, primary bone grafting with rib bone in infancy was standard, but it often led to complications like midface retrusion and anterior crossbite. Now, secondary bone grafting during (15–20 years) is preferred as it has positive outcomes [10].

Several benefits and objectives of bone grafting obtains maxillary arch continuity, stabilizes maxillary segments after orthodontic treatment, especially the removable primary palate of bilateral clefts, maximizes bone support for dentition, eliminates oronasal fistulae, provides nasal alar cartilage support, establish ideal alveolar morphology, and provides available bone with attached soft tissue for future endosteal implant placement where there is a residual dental space [11–13].

Artificial bone materials such as hydroxyapatite and tricalcium phosphate are mixed with rhBMP, but there may be teratogenic and carcinogenic effects because of overgrowth [14]. Recent studies investigating the addition of growth factors such as PRP and platelet-rich fibrin (PRF) with graft materials have been carried out during bone grafting, but these methods have not yet been widely used [15].

Both cancellous and cortical bones are viable for bone grafts in the management of alveolar clefts. Cancellous bone is preferred as it has superior osteoinduction and revascularization properties. Multiple sources, including autologous, allogeneic, xenogeneic materials, rhBMP, and growth factors, have been used, but fresh autologous cancellous bone remains the ideal choice [16]. The iliac crest is a common site for bone graft harvesting because it allows for concurrent cleft preparation and provides a large quantity of cancellous bone. Although, its use can lead to scarring, postoperative pain, and nerve injury risks [12]. Trephine techniques can minimize these complications by reducing operative time and pain, as shown in studies by Ilankovan *et al.* [17] and Sharma *et al.* [18]. Cranium, another source, has advantages like less resorption and hidden scarring but with risks such as hematoma and cerebrospinal fluid leakage [16]. Tibia is a less common source, offering reduced bleeding and quicker recovery, though its use in children is limited as it may lead to growth disturbances [18]. Lastly, the mandibular symphysis, sharing embryonic origin with the maxilla, allows faster revascularization and reduced hospital stay, but comes with the risk of damaging teeth and nerves and is limited by the development of the mandible [19].

Allogeneic bones as demineralized freeze-dried bone allograft or demineralized bone matrix for osteoinduction, and freeze-dried bone for osteoconduction are used as substitutes for autologous grafts [16]. Risks include infection and incompatibility. Artificial bone materials, such as hydroxyapatite and tricalcium phosphate mixed with rhBMP, have potential risks like overgrowth. Growth factors like PRP are being explored as additives, although not widely used yet [20].

Historically, primary ABG was common, but it caused maxillary growth disturbances. Secondary bone grafting, introduced in the 1970s, proved more effective for stabilizing the maxilla without growth restriction [16].

Autogenous bone grafts from intraoral sites offer advantages like reduced morbidity in anterior maxilla defects. In cleft patients, dental implants require careful planning because of esthetic demands and bone volume considerations. Treatments often involve re-augmentation of the cleft jaw and close collaboration between surgeons and implantologists [21].

2. Aim

This project aims to develop a framework to investigate the efficacy of PRP in conjunction with bone grafting and dental implantation in patients with alveolar clefts, evaluating outcomes in terms of healing, integration, and overall improvement in dental function and esthetics.

3. Patients and methods

3.1. Study population

This prospective randomized study was implemented on 30 patients aged 15–20 years from both rural and urban areas in Qalyobia and Cairo governorates from September 2022 to March 2024.

3.2. Ethical considerations

Written and signed informed consent was obtained from the parents or guardians of all participants prior to their inclusion in the study.

3.3. Inclusion criteria

Participants in this study had to be aged between 15 and 20 years old and diagnosed with a unilateral alveolar cleft. They were scheduled to undergo ABG and dental implantation. It was crucial that they were in adequate general health to safely undergo surgical procedures under general anesthesia. Eligibility also required that they had not received any previous surgical treatment for the alveolar cleft.

3.4. Exclusion criteria

Patients were excluded from the study if they had associated congenital anomalies, which could potentially influence the outcomes of the procedures being evaluated. Additionally, exclusion criteria included patients with poor oral hygiene due to the higher risk of postoperative complications and a possible impact on the success of bone grafting and dental implantation. Those who were suffering from acute tonsillitis, pharyngitis, or other acute oral infections at the time of enrollment were also ineligible, as these conditions could complicate the surgery and its subsequent healing process. Finally, any patient who exhibited a high temperature (over 38 °C) on the day of enrollment was excluded to mitigate the risks associated with performing surgery on individuals potentially suffering from an underlying infection or inflammatory condition.

3.5. Methods

Patients were divided into two equal groups:

The group 1 was treated with bone grafting and PRP injection in the alveolar cleft followed by dental implant placement under general anesthesia. Group 2 underwent bone grafting without PRP injection in the alveolar cleft, followed by dental implant placement under general anesthesia.

Participants will undergo the following evaluations:

In the study, comprehensive data collection included each participant's personal information, dietary habits, and socioeconomic level. Additionally, a detailed medical history was gathered, focusing on long-term treatments and chronic diseases. Essential medical investigations such as erythrocyte sedimentation rate (ESR), C - reactive protein (CRP), RBS, and complete blood count (CBC) were conducted to assess the overall health of the patients. A complete medical examination was also performed, with a focus on identifying skin conditions and any other congenital anomalies, ensuring the suitability and safety of each participant for the surgical procedures.

3.5.1. Platelet-rich plasma preparation

Preparation of PRP began with patients sitting comfortably. After a good aseptic technique, the right amount of venous blood was collected for PRP using sterile, single-use needles and syringes. Depending on wound size, each patient provided 10−60 ml of venous blood. The blood had been combined with 1.25 ml of citrate phosphate dextrose per 10 ml in a sterile tube. Two-step centrifugation on a benchtop centrifuge produced PRP. Fifteen minute centrifugation at 3000 rpm divided the blood into plasma, buffy coat, and red blood cells. After that, plasma and buffy coat were aspirated into another sterile tube without anticoagulants and centrifuged at 2000 rpm for 5 min. This separated the platelet-poor plasma in the upper tube from the PRP in the lower section. Then PRP was carefully kept, whereas the platelet-poor plasma was discarded or used for larger wounds. Calcium gluconate (10 %, 9:1) had been added immediately before usage to produce PRP. This addition created a wound-adhering gel film or prepared PRP for direct injection.

3.6. Surgical technique

Osteoplasty of the alveolar cleft was performed under general endotracheal anesthesia with prophylactic intravenous antibiotics, specifically amoxicillin/clavulanic acid (30−50 mg/kg). Autogenic spongy bone had been harvested from the anterior iliac crest, with a 2 cm long skin incision made 1 cm laterally to the crest. Precise dissection had been made to expose the iliac crest and harvest cancellous bone. An osteotome makes two perpendicular horizontal cuts to obtain a block of corticocancellous bone and to minimize the risk of peritoneal penetration. The surgical site was then irrigated and closed with layers, using microfibrillar collagen for hemostasis, without drains or pressure dressings. Local anesthesia with epinephrine was applied to the cleft area for pain control. Two mucoperiosteal flaps had been created for grafting, and nasal mucosa had been separated by an incision from the gingiva on both sides of the maxilla, with bone placed near the piriform aperture for structural support. A bone graft could be taken in a block and fixed with screws. The operation area had been closed with a flap and secured with a resorbable suture. Postsurgery, patients received instructions for oral hygiene and pain management [22].

3.7. Implant and prosthodontic rehabilitation

Dental anomalies like impacted teeth and tooth agenesis are common in cleft patients. After

successful osteoplasty, options to address tooth loss, typically the lateral incisor, include orthodontic treatment, adhesive bridgework, tooth transplantation, and implants, depending on the specific dental needs. Mucosal flaps had been made to prepare the bone for the implant to be inserted by drilling to place the fixture into the bone by screwing, then the flaps were closed. After implant integration, abutment was placed to support the connection between the crown and the implant. Second incision was done with abutment placement, and an impression was taken for crown making. Then, the final crown was cemented on the abutment. Follow up for 1 year for evaluation of outcomes with radiograph for bone density, healing, integration, and overall improvement in dental function, stability, and esthetics.

4. Results

4.1. Patient's characteristics

The characteristics of the patients in the two groups are presented in Table 1. There were no differences between the groups regarding the distribution of males and females ($P = 0.269$), age ($P = 0.521$), patient compliance ($P = 1.0$), or oral hygiene ($P = 1.0$). Both groups had a ratio of males to females, with 46.7 % males in group 1 and 66.7 % males in group 2. The average ages were 12.60 ± 2.69 years for group 1 and 13.27 ± 2.91 years for group 2, respectively. An equal percentage of patients in each group were compliant (66.7 %). Good oral hygiene was in 66.7 %.

4.2. Mobility

The mobility of the implanted tooth showed a significant difference between group 1 and group 2. In group 1, only one (6.7 %) patient exhibited no mobility, compared to 10 (66.7 %) patients in group 2, resulting in a highly significant P value of 0.001. Additionally, seven (46.7 %) patients in group 1 showed "somewhat" mobility, versus five (33.3 %) patients in group 2. Notably, seven (46.7 %) patients in group 1 were categorized as "mobile," while in group 2, no patients (0.0 %) fell into this category (Fig. 1).

4.3. Clinical outcomes and patient satisfaction

Table 2 shows clinical results and satisfaction for group 1 and group 2 patients. The two groups had similar infection rates, with 26.7 % of patients in each group getting infections and 73.3 % being infection-free ($\chi^2 = 0.0$, $P = 1.0$). Both groups had 13.3 % implant failure and 86.7 % successful implants ($\chi^2 = 0.0$, $P = 1.0$). Other problems, such as donor site pain, symptomatic scars, and tooth protrusion, did not differ across groups ($\chi^2 = 0.381$, $P = 0.944$). No significant differences were seen in patient satisfaction. Both group 1 and group 2 had 73.3 % pleased patients, while 13.3 and 20.0 % were slightly satisfied. Dissatisfaction was 13.3 % in group 1 and 6.7 % in group 2. Importantly, group 1 and group 2 patient satisfaction was similar ($\chi^2 = 0.533$, $P = 0.766$).

4.4. Time-related variables

Table 3 compares time-related variables between the two study groups. There were no significant differences between groups in the mean time for bone grafting ($P = 0.470$) or mean healing time ($P = 1.0$). However, significant differences were found in the mean time for loading ($P = 0.001$) and mean osteointegration time ($P = 0.001$). Specifically, the mean loading time was shorter in group 1

Table 1. Patient characteristics in the studied groups.

Variables	Group 1 ($N = 15$)	Group 2 ($N = 15$)	Significant test	P value
Sex			$\chi^2 = 1.222$	0.269
Male	7 (46.7)	10 (66.7)		
Female	8 (53.3)	5 (33.3)		
Age	12.60 ± 2.69 Range: 15–20	13.27 ± 2.91 Range: 15–20)	t-test = 0.651	0.521
Patient compliance			$\chi^2 = 0.0$	1.0
Yes	10 (66.7)	10 (66.7)		
No	5 (33.3)	5 (33.3)		
Oral hygiene			$\chi^2 = 0.0$	1.0
Good	10 (66.7)	10 (66.7)		
Bad	5 (33.3)	5 (33.3)		

Data are represented as mean ± SD, range, or n (%).
P value for comparing between the two studied groups.

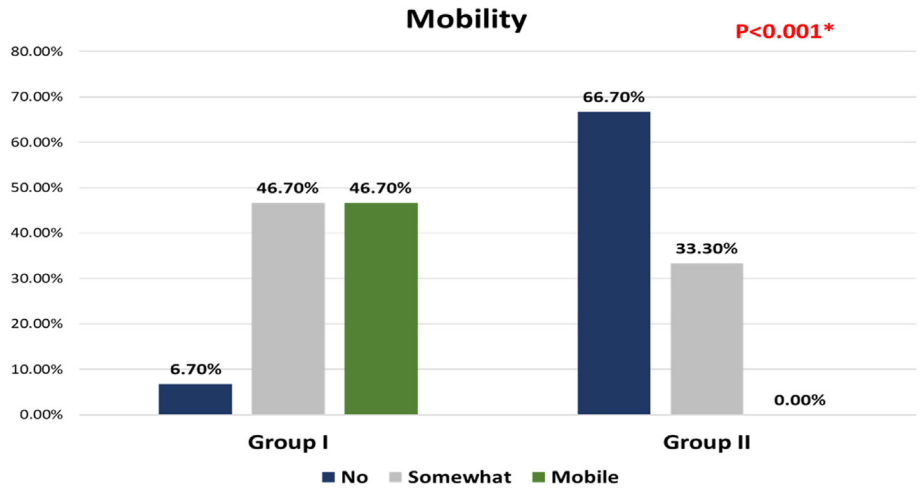

Fig. 1. Mobility in the studied groups.

Table 2. Clinical outcomes and patient satisfaction in the studied groups.

Variables	Group 1 ($N = 15$)	Group 2 ($N = 15$)	Significant test	P value
Infection			$\chi^2 = 0.0$	1.0
Yes	4 (26.7)	4 (26.7)		
No	11 (73.3)	11 (73.3)		
Failure of implant			$\chi^2 = 0.0$	1.0
Yes	2 (13.3)	2 (13.3)		
No	13 (86.7)	13 (86.7)		
Other complication			$\chi^2 = 0.381$	0.944
No	10 (66.7)	11 (73.3)		
Pain at the donor site	2 (13.3)	2 (13.3)		
Symptomatic scar	2 (13.3)	1 (6.7)		
Tooth protrusion	1 (6.7)	1 (6.7)		
Patient satisfaction			$\chi^2 = 0.533$	0.766
Satisfied	11 (73.3)	11 (73.3)		
Somewhat satisfied	2 (13.3)	3 (20.0)		
Not satisfied	2 (13.3)	1 (6.7)		

Data are represented as *n* (%).
P value for comparing between the two studied groups.

Table 3. Comparison of time-related variables in the studied groups.

Variables	Group 1 ($N = 15$)	Group 2 ($N = 15$)	Significant test	P value
Time for bone grafting	12.80 ± 2.40 10–17	13.47 ± 2.59 10–18	*t*-test = 0.732	0.470
Time of healing	14.33 ± 1.72 12–18	14.33 ± 1.72 12–18	*t*-test = 0.0	1.0
Time of loading (days)	7.07 ± 1.10 6–9	10.13 ± 1.19 9–12	*t*-test = 7.34	0.001[a]
Time of osteointegration	15.20 ± 2.68 12–20	7.07 ± 1.10 6–9	*t*-test = 10.88	0.001[a]

Data are represent as mean ± SD, range.
P value for comparing between the two studied groups.
[a] Statistically significant at *P* value less than or equal to 0.05.

(7.07 ± 1.10 days) compared to group 2 (10.13 ± 1.19 days). In contrast, the mean osteointegration time was longer in group 1 (15.20 ± 2.68 days) versus group 2 (7.07 ± 1.10 days) (Figs. 2–12).

5. Discussion

CLP are common congenital anomalies affecting the orofacial area [1]. ABG during mixed dentition

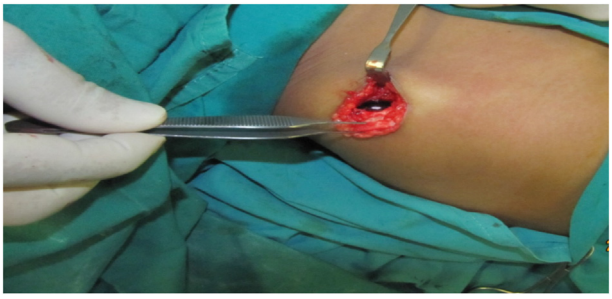

Fig. 2. Incision to expose iliac spine.

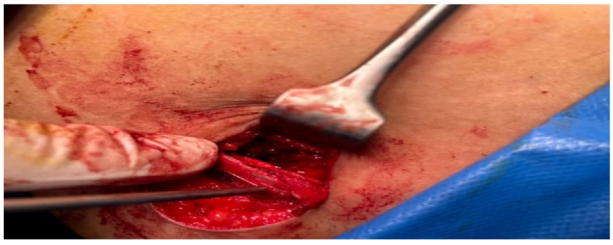

Fig. 3. Exposed iliac spine.

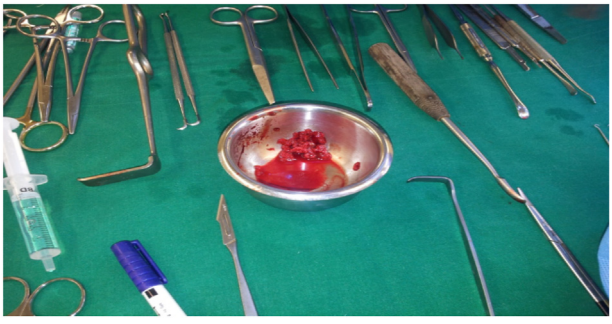

Fig. 4. Harvested cancellous bone graft.

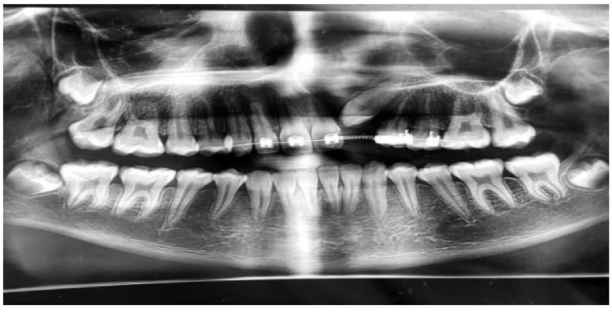

Fig. 5. Digital panoramic radiograph showing bony cleft.

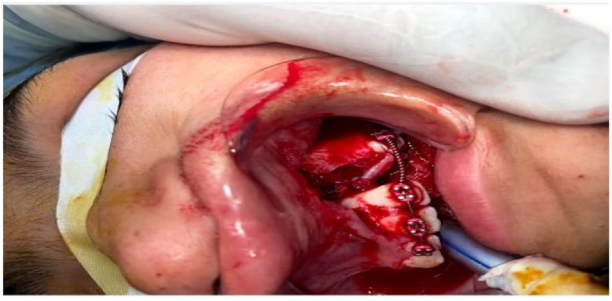

Fig. 6. Mucosal flap to expose the cleft.

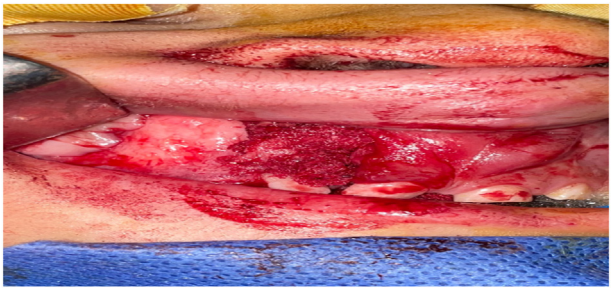

Fig. 7. Harvested bone graft placed in the cleft.

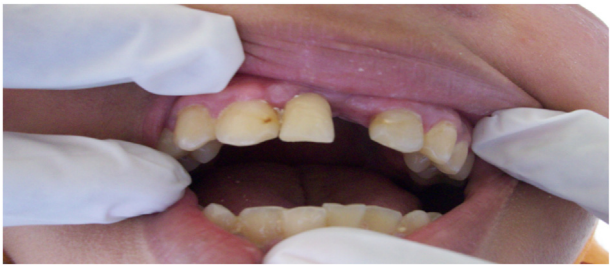

Fig. 8. After grafting of the cleft.

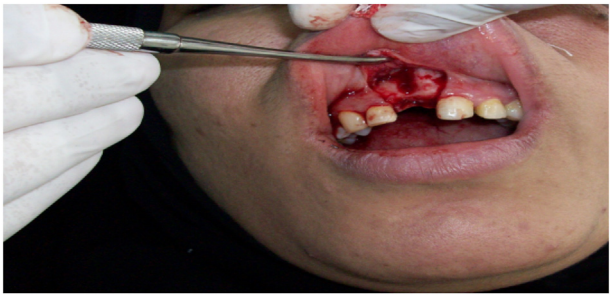

Fig. 9. Mucosal flap elevated for implant insertion.

facilitates proper canine eruption by regenerating bone across the cleft site. Autografts from ilium provide abundant osteogenic cells, making them the gold standard. However, graft failures have been documented, especially around the alar base and alveolar ridges [2]. PRP contains growth factors that promote healing [23]. Combining PRP injections with bone grafts during secondary ABG has shown benefits, including enhanced early bone growth, increased bone density, and reduced resorption [24].

This study was implemented on about 30 patients from 15 to 20 years old from Qalyobia and Cairo

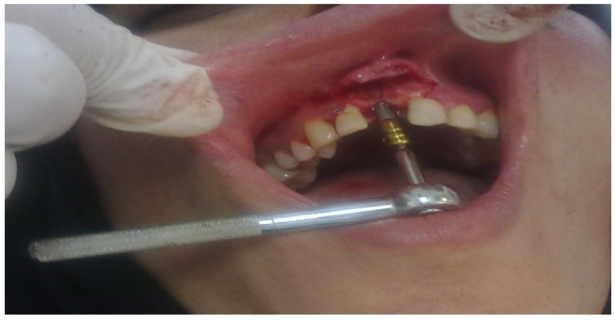

Fig. 10. Loading the fixture.

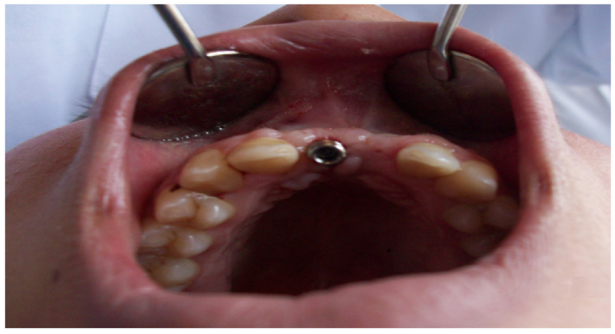

Fig. 11. Abutment placed for the dental implant.

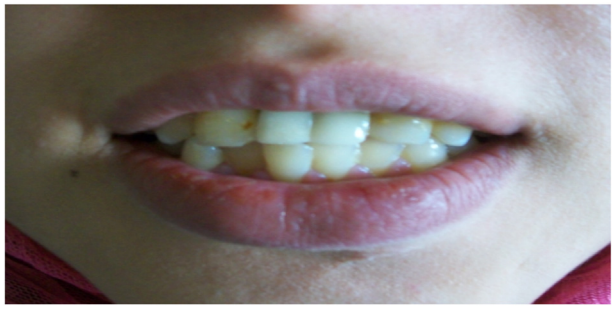

Fig. 12. After crown insertion.

governorates, including rural and urban areas. Patients were divided into two groups. First group had been treated by bone grafting with PRP injection in the alveolar cleft and dental implant under general anesthesia. Second group was treated by bone grafting without PRP injection in the alveolar cleft and dental implant under general anesthesia. The mean age for group 1 (mean ± SD) was 12.60 ± 2.69, while it was 13.27 ± 2.91 for group 2 ($P = 0.521$) with no significant difference.

The recommended time frame for performing secondary alveolar cleft repairs falls between 15 and 20 years of age. Typically, children born with cleft lip, alveolus, or palate have already undergone several surgeries contributing to the presence of significant scar tissue, such as lip closure at around 3 months after birth and palate repair at ~2 years of age [25].

In our study, with regard to patient compliance, a nonsignificant difference was observed between study groups ($P = 1.0$). Also, in comparing the study groups, no statistically significant difference was observed regarding the failure of the implant. As well as no significant difference was found with regards to the incidence of infection between the two groups. Additionally, the percentage of patients with no complications was similar between groups, at 66.7 % for group 1 and 73.3 % for group 2 ($P = 0.944$). The most common complications were pain at the donor site, occurring in 13.3 % of both groups and symptomatic scarring at the donor site in 13.3 % of group 1 and 6.7 % of group 2 patients. Tooth protrusion was relatively uncommon but equal at 6.7 % in both groups. There were no statistically significant differences in complication rates between the two groups, with about 25–30 % of patients in both groups experiencing pain, scarring issues, or tooth protrusion.

In agreement with Gupta *et al.* [25], this study compared outcomes between group 1, who received PRP injection with bone grafting for secondary ABG, and group 2, who received bone grafting alone. There was a clinically higher but statistically nonsignificant rate of graft rejection in group 2 compared to group 1. Rates of complications like graft loss, wound dehiscence, infection, and oronasal fistula redevelopment tended to rise with age. These age-related differences did not reach statistical significance. All patients, postoperatively, were able to mobilize the day after surgery and resume normal walking within 1 week.

A study by McGurk *et al.* [26] used a hand-operated trephine that penetrated to a length of 8 cm. Their study of 20 patients found no complications and less postoperative pain.

Osman *et al.* [27] conducted a study to evaluate the effectiveness of PRP in combination with iliac crest bone graft (ICBG) compared to conventional ICBG for alveolar cleft reconstruction. This study included 10 patients in group 1 who received ICBG with PRP and 10 patients in group 2 (control group) who underwent ICBG alone. Findings revealed that group 2 patients had a higher rate of complications, with a 30 % infection rate, and 10 % experienced postoperative bleeding, necessitating conservative treatments such as antibiotics and/or packing for resolution. However, despite the increased rate of complications in group 2, all patients in both group 1 and group 2 achieved successful healing without major issues like graft loss

or the need for additional surgery. In summary, group 2 exhibited more complications, but these were effectively managed with conservative treatments, leading to positive outcomes in both groups.

A retrospective analysis of data collected from Weibrich *et al.* [28] showed that the blood draw and PRF preparation procedures were performed without any complications or adverse events.

A retrospective study by Marukawa *et al.* [29] reported that PRP inhibits bacterial growth due to its acidic pH (6.5–6.7), which creates an unfavorable environment for bacteria. Additionally, PRF concentrates white blood cells and platelets, increasing the number of versatile leukocytes to combat bacteria. Promotes the rapid development of granulation tissue by enhancing capillary in-growth, which attracts macrophages and neutrophils to further inhibit bacterial growth and facilitate tissue healing.

Man *et al.* [30] found successful healing without graft rejection in all cases treated with autogenous graft combined with PRP. In contrast, Seike *et al.* [22] observed longer-lasting pain in patients treated with autogenous graft alone compared to those who received a combination of PRP and autogenous graft. Additionally, Strayhorn *et al.* [31] reported the absence of oronasal fistula in all treated cases.

We described that in comparing study groups, no statistically significant difference was observed regarding patient satisfaction. There was a statistically nonsignificant difference between the two groups regarding time for bone grafting. The results are expressed in percent with a statistically significant difference found between the two groups as regard to time of loading being lower in group 1. In our study, the mobility of implanted tooth shows a significant difference. In our study, there was a statistically nonsignificant difference between the two groups regarding the time of healing.

In our study, primary healing with PRP was consistent with findings from previous research [30,32]. Marukawa *et al.* [29] observed reduced bone resorption postoperative with PRP. Marx *et al.* [33] reported that the addition of PRP to milled bone grafts increased bone formation rates, suggesting growth factors enhance alveolar bone regeneration. However, Luaces Rey *et al.* [34] found nonsignificant differences in bone regeneration between therapeutic groups based on digital orthopantomographs.

A recent systematic review by Vishva *et al.* [35] noted the PRP group showed increased bone remodeling, but the long-term effectiveness of PRP in preventing bone resorption after subsequent transplantation into alveolar clefts remains uncertain when combined with transplantation techniques. Gupta *et al.* [25] showed that combining autologous bone chips from the iliac crest with PRP promoted bone formation in alveolar clefts, leading to accelerated bone formation, increased density, fewer infections, and minimal postoperative discomfort. Sakio *et al.* [36] found no significant reduction in postoperative bone resorption with PRP.

Bezerra *et al.*'s [37] pilot study demonstrated positive outcomes when using combined PRP with bovine graft (Bio-Oss) for alveolar cleft repair, offering a viable alternative when autologous bone was unavailable. Other studies have also reported enhanced bone density and graft integration with PRP-augmented grafting, leading to faster healing and reduced graft-related complications [29,38].

In the current study, group 1 has a range of 12–20 weeks, and group 2 ranges from 6 to 9 weeks. Mean time of osteointegration for group 1 is 15.20 weeks with a SD of 2.68, while group 2 has a mean time of 7.07 weeks with a SD of 1.10. A *t*-test was conducted, revealing a statistically significant difference between the two groups ($t = 10.880$, $P = 0.001$). The results suggest that the osteointegration process in group 1, with a wider range and a longer mean time, differs significantly from group 2, which has a shorter and more consistent time frame for osteointegration.

PRP has been associated with increased bone mineral density in grafts, with reported values ranging from 1.6 to 2.2 times that of non-PRP-assisted grafts [33]. Lee *et al.* [39] suggested that PRP may enhance bone remodeling in the early phase but may not be sufficient as a long-term countermeasure against bone resorption following secondary bone grafting. MacIsaac *et al.* [40] used supplemental demineralized bone matrix and allograft, observing various outcomes in canine eruption.

PRP's effects on bone grafts were beneficial, improving bone regeneration and enhancing the maturity of grafted bone, resulting in a more mature Harversian system and a greater proportion of the lamellar phase [41]. Osman *et al.* [27] found that PRP enhances bone density when used with iliac bone grafts. However, other studies suggested that PRP alone may not fully prevent bone resorption following secondary bone grafting [42].

In contrast, Lee *et al.* [39] reported successful outcomes when using PRP in combination with supplemental demineralized bone matrix and allograft. PRP has also been shown to increase the density of osteoblasts in rabbit maxillary bone grafts, affecting collagen and osteoblasts in the early stages of hard callus formation and ultimately promoting osteogenesis [40].

Adequate bone volume was critical for dental implant stability. In cleft repair patients, supplemental bone grafting, like nasal floor coverage, may be needed where the bone stock is deficient. Hydroxyapatite-coated implants further promote integration and stability compared to smooth titanium. Superior bioactivity of the hydroxyapatite surface enhances osseointegration, which is particularly important in complex cases with extensive grafting and pre-existing scar tissue [43]. Three-dimensional bone volumetric analysis revealed that postoperative bone resorption can lead to a decrease in the interdental alveolar crest level. A prolonged time between implant placement and second implant surgery may result in nonfunctional bone atrophy. Successful bone grafting typically requires a minimum of 12.5 weeks to provide primary stability. Additionally, unfavorable implant positions and angulations may induce marginal bone loss because of localized stress shielding [44,45].

5.1. Conclusion

In conclusion, our study demonstrated that the incorporation of PRP may contribute to a faster loading time and potentially improved stability of implanted teeth in pediatric patients with alveolar clefts. However, further research with larger sample sizes is warranted to validate these findings and assess the long-term outcomes of this treatment approach. Limitations of this study included a small sample size and, a short follow-up period.

Ethics information

The study was approved by The institutional committee's ethical criteria were followed during all proceedings. The Ethics Committee of the Scientific Research, GOTHI, Ministry of Health, Egypt approved the study (No. HB000116). Following an explanation of the purpose, procedures, and nature of the study to all participants, signed informed consent was obtained from each participant.

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Author contribution

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Conflicts of interest

No conflict of interest.

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