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Digital Workflow among Dentists in Cleft Lip and Palate Cases: A Cross-Sectional Study

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Abstract

Introduction: Neonatal impressions for cleft lip and palate (CLP) using alginate or polyvinyl siloxane are associated with risks of aspiration, airway obstruction, and soft-tissue distortion, which complicates presurgical orthopedics such as nasoalveolar molding (NAM) [1]. Intraoral scanning (IOS) offers a contactless, reproducible alternative that integrates seamlessly with CAD/CAM workflows [2].

Objective: To evaluate the knowledge, attitude, and practice (KAP) regarding digital workflows in CLP management among dental specialists, and to compare these across Prosthodontics, Orthodontics, Pedodontics, and Oral Surgery.

Methods: A cross-sectional survey (March–May 2024) was conducted among 220 postgraduate students and practitioners at a tertiary dental institute in Belagavi, India. A 16-item validated questionnaire assessed KAP; data were analyzed with chi-square tests and ANOVA in SPSS v.26 ($\alpha = 0.05$).

Results: Respondents were 35% male and 65% female; 72.7% were aged 24–27 years; 75.9% had ≤5 years'

experience. Familiarity with digital workflows was highest among Orthodontists (83%) and lowest among Oral Surgeons (45%). A positive attitude was expressed by 78.2% overall (faculty 91.8% vs. postgraduates 73%, p = 0.008); positivity increased with experience (0–5 yrs: 72.5%; >10 yrs: 100%, p < 0.001). Although 10% had practical IOS experience in CLP cases, 89.5% believed digital impressions will become the standard of care. Main barriers were lack of training (64%), equipment cost (58%), and infrastructure limitations (45%).

Conclusions: Despite strong awareness and favorable attitudes toward IOS in CLP care, practical adoption remains limited by educational and financial constraints. Recommendations include integrating IOS into curricula, hands-on workshops, and collaborative funding models for equipment acquisition.

Keywords: Digital Workflow, Cleft Lip and Palate, Intraoral Scanning, 3D Printing, Digital Impressions, CAD/CAM Dentistry, Nasolabial Molding (NAM), Dental Technology

Introduction

Cleft lip and palate (CLP) are among the most prevalent congenital craniofacial anomalies, affecting approximately 1 in 700 live births globally [3]. Early management focuses on presurgical orthopedics—such as nasoalveolar molding (NAM)—which require precise impressions of the alveolar segments and surrounding soft tissues to fabricate customized molding plates that guide maxillary growth and optimize surgical outcomes [4].

Conventional Impression Challenges

Traditionally, impressions in neonates with CLP employ irreversible hydrocolloids (alginate) or rapid-set polyvinyl siloxanes. These techniques are associated with risks such as aspiration and soft-tissue distortion. Chate[1] documented instances of alginate aspiration requiring intervention, underscoring the hazards of these conventional methods. Moreover, these materials undergo polymerization shrinkage, distortion, and void formation, compromising dimensional accuracy—especially in discontinuous cleft arches with deep undercuts[5].

Digital Intraoral Scanning (IOS)

Since their introduction in the 1980s, intraoral scanners (IOS) have evolved to provide ultra-fast, high-resolution surface capture without the need for traditional impression materials. These scanners employ structured light and confocal microscopy to reconstruct three-dimensional (3D) meshes in real time, with minimal artifacts[2]. IOS advantages include the elimination of physical impression materials, immediate data visualization, and seamless integration with CAD/CAM workflows for appliance design [6].

Applications in CLP Care

Patel et al.[7] first reported the use of IOS in a neonate with bilateral CLP, demonstrating clinically acceptable deviations (within ±0.8 mm compared to conventional models) and noting the absence of material-related complications. Benítez et al.[8] extended these findings across two European centers, reporting the absence of adverse events in 190 patients (aged up to six years) with median palatal scan times of 85.5 seconds and lip/nose scans of 50 seconds. In addition, systematic reviews have highlighted improved patient comfort and reduced procedural time with digital methods, though current software often requires adaptation for discontinuous cleft segments [9].

Barriers to Adoption

Despite the clinical advantages, IOS uptake in CLP care remains inconsistent, particularly in resource-limited settings. Key barriers include high capital costs for

hardware and CAD/CAM infrastructure (approximately USD 20,000–30,000 per unit) [10], lack of formal training in digital techniques during dental education [11], and software algorithms optimized for contiguous adult dentitions that may misinterpret discontinuous cleft anatomy as noise [12].

Study Purpose

This study evaluates the KAP regarding digital workflows in CLP management among dental specialists at an Indian tertiary institute to identify the barriers and facilitators. The findings aim to inform targeted educational and policy interventions.

Materials and Methods

Study design

According to reporting criteria for Strengthening the Reporting of Observational Studies related to Epidemiology, the present research employed a cross-sectional, observational study design.

Study setting

The study was carried out between postgraduate students and dental professionals of Department of Prosthodontists, Orthodontists, Pedodontists, Oral Surgery of KAHER'S V. K. Institute of Dental Sciences, Belagavi, Karnataka.

The survey conducted between March, April, and May 2024.

Eligibility criteria

All dental college participants who were willingly able to provide informed permission were added in the study. People who all refused for consent for the participation in the study were not included.

Questionnaire validation

Five participants in each group participated in a pilot study to find questionnaire issues and other issues pertaining to the questionnaire. Cronbach's α calculated the reliability related to the questionnaire, confirmed by the content validity ratio (0.75), face validity (83%). Based on this, the questionnaire was corrected through feedback and making it better as well as specific to the aim of the study, thereby providing acceptable questionnaire.

Questionnaire characteristics

Sixteen English-language, closed-ended items were included in the survey. 4 questions were of knowledge, 7 questions were based on attitude and 5 questions were practice based.

A total of 220 subjects including dental students as well as professionals were sent a validated questionnaire link via internet through social media (WhatsApp groups), with the informed consent.

The participants were given instructions to try each one of the sixteen questions. The questionnaire's first part asked about the participant's age, gender, years of experience, and current state of practice; this information helped with qualitative analysis of the participants. The second part asked about the participant's knowledge, attitude, and practice of Digital Workflow Among Dentists in Cleft Lip and Palate Cases.

Bias

A single researcher gave the questionnaire at a predetermined time and day in a classroom. The entire process was closely monitored to minimise bias. Volunteers guarantee that the questionnaire is completed objectively. This technique assisted in maintaining the integrity. Responses were not influenced by other participants.

Sample size estimation and sample distribution

Using G* Power statistics software (Ver .3.1.9.4), the pilot study determined a minimum sample size of 340 with a type I (α) error of 0.05 and power (1-β) of 0.95. Using G* Power statistics software (Ver .3.1.9.4), the pilot study determined a minimum sample size of 220

with a type I (α) error of 0.05 and power (1-β) of 0.95. We obtained a list of participants from KAHER'S V. K. Institute of Dental Sciences, Belagavi, covering a range of affiliations. From a list, participants were selected randomly. Consequently, 220 samples in total were obtained.

Ethical Considerations

Ethical approval was obtained from the institutional review board, and participants provided informed consent before completing the questionnaire.

Statistical Analysis

Data were analyzed using SPSS software version 26. Descriptive statistics summarized participant responses. Chi-square tests and ANOVA were conducted to assess differences in knowledge and practice levels across dental specialties. A p-value of <0.05 was considered statistically significant.

Results

All 220 invitees completed the survey (response rate: 100%). Table 1 summarizes the demographics of the study participants. Respondents were predominantly female (65%), aged 24–27 years (72.7%), and early-career professionals (75.9% had ≤5 years' experience). The specialty distribution was as follows: Prosthodontics: 45.9%, Orthodontics: 19.1%, Pedodontics: 20.9%, Oral Surgery: 14.1%. Postgraduates constituted 72.3% of participants, with the remainder being faculty or practicing professionals.

Knowledge

- Mean knowledge scores (± SD) among specialties were as follows:
- Prosthodontists: 2.35 ± 1.099
- Orthodontists: 2.33 ± 0.902
- Pedodontists: 2.41 ± 1.147
- Oral Surgeons: 2.39 ± 1.230 Overall total: 2.36 ± 1.087.

Attitude

- Overall, 78.2% of the participants had a positive attitude towards the digital workflow in CLP cases. Breakdown of positive attitude is as follows:
- By years of experience:
- 0–5 years: 72.5%
- 5–10 years: 94.3%
- 10–15 years: 100%
- >15 years: 100%
- By designation:
- Postgraduates: 73%
- Faculty/Practitioners: 91.8%
- By specialty:
- Prosthodontists: 89.1%
- Orthodontists: 57.1%
- Pedodontists: 76.1%
- Oral Surgeons: 74.2%.

Practice

Impression Techniques Employed in CLP Cases

- Traditional methods: 36.8%
- Digital impressions: 56.8%
- Hybrid approaches: 6.4%

Perception of Digital Impressions as the Standard of Care

- Yes: 89.5%
- No: 10.5%
- **Challenges Faced in Using Digital Tools**
- Yes: 16.8%
- No: 83.2%

Knowledge and Adoption of Digital Workflow

Familiarity with digital workflow among the specialties was as follows: 65% of Prosthodontists, 83% of Orthodontists, 78% of Pedodontists, and 45% of Oral Surgeons. Although 89.5% considered digital impressions as the future standard of care for CLP cases,

only 10% had hands-on experience with digital impressions (see Figure 1).

Perceived Barriers

- Lack of training: 64%
- High equipment costs: 58%
- Infrastructure limitations: 45%
- Concerns regarding accuracy in deep cleft regions: 32% (see Figure 2).

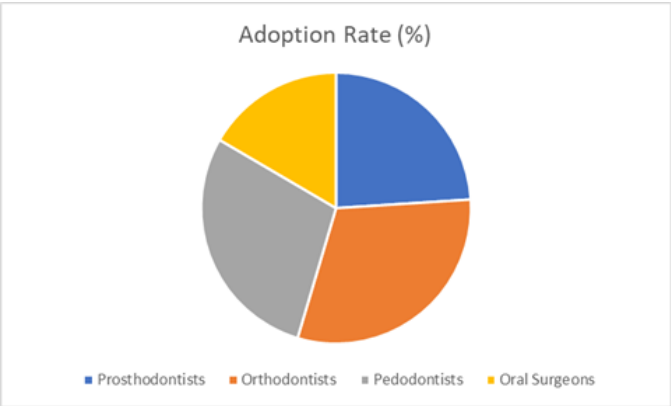
Table 1: Demographics of Study Participants

Variable		Frequency	%
Gender	Male	77	35.0%
	Female	143	65.0%
Age	20-23	4	1.8%
	24-27	160	72.7%
	28-31	22	10.0%
	32-35	12	5.5%
	>35	22	10.0%
Experience	0-5 years	167	75.9%
	5-10 years	35	15.9%
	10-15 years	5	2.3%
	>15 years	13	5.9%

Table 2: Knowledge and Adoption of Digital Workflow

Specialty	Familiarity with Digital Workflow (%)	Used Digital Impressions (%)
Prosthodontists	65%	12%
Orthodontists	83%	20%
Pedodontists	78%	18%
Oral Surgeons	45%	8%

Figure 1: Digital Workflow Adoption among Specialties



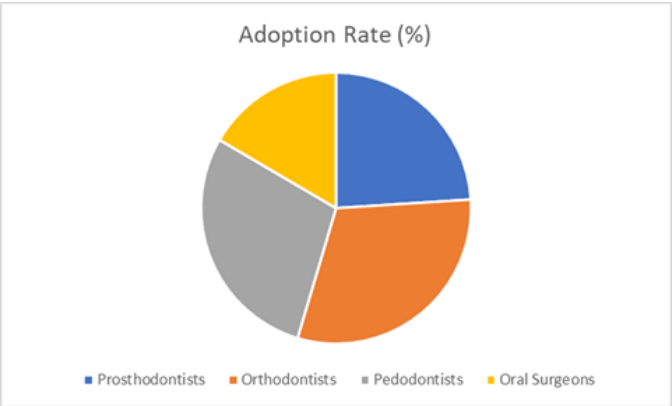


Figure 2: Challenges in Implementing Digital Workflow

Discussion

This study represents the first comprehensive KAP survey of digital workflows in CLP management among Indian dental specialists. Key findings include:

High Awareness, Low Practical Uptake: Although there was a high level of exposure to CLP cases and 56.8% reported familiarity with IOS, only 10% had actual hands-on experience—revealing a significant gap between theoretical knowledge and clinical implementation.

Positive Attitudes with Increasing Experience: The data demonstrated that more experienced clinicians exhibited a higher positive attitude towards IOS. With clinical experience over 10 years yielding 100% positivity, it appears that increased exposure builds confidence in the digital workflow.

Specialty-Specific Variations: There were notable differences among specialties. For instance, Orthodontists showed the highest familiarity (83%) with digital workflows, yet had the lowest positive attitude (57.1%). This finding may be related to current software limitations in accurately capturing discontinuous cleft anatomy [12]. In comparison, Prosthodontists, who are more accustomed to digital CAD/CAM processes, showed both high familiarity and a very positive attitude (89.1%).

Clinical Implications: IOS in CLP care has been shown to be safe, efficient, and time-saving—with some studies reporting scan times under two minutes [7,14]. Digital impressions eliminate the potential risks and inaccuracies of conventional materials [5], facilitate immediate data visualization, and help streamline workflows for NAM and surgical planning [6,15]. The potential for improved interdisciplinary communication and telemedicine in cleft care is equally promising.

Educational and Financial Barriers: Our findings indicate that a lack of training (64%) significantly hampers the practical adoption of IOS. Integrating digital dentistry modules, simulation labs, and hands-on workshops into postgraduate and continuing education should be prioritized [11]. Meanwhile, the high cost of equipment (reported by 58% of participants) suggests that collaborative funding models or manufacturer educational discounts could be viable solutions [10].

Technical Challenges: Scanner software, predominantly optimized for contiguous adult dentition, sometimes misinterprets the discontinuous cleft segment as noise. Enhancing these algorithms—by adjustable noise filters and improved segmental stitching—could reduce manual corrections and increase clinician confidence [12].

Strengths and Limitations: The study's strengths include a 100% response rate and a balanced representation of dental specialties. However, the single-center design and reliance on self-reported data might limit broader generalizability. Future multicenter studies should consider objective scan quality assessments, time-motion analyses, and cost-effectiveness evaluations.

Future Directions

- **Clinical Outcomes Research:** Future studies should compare fit accuracy, patient comfort, and long-term outcomes between digital and conventional impression cohorts.
- **Cost-Effectiveness Analyses:** Evaluating the return on investment for IOS, considering reduced chair time and material savings, would be beneficial.
- **Technological Advancements:** Collaborations with scanner manufacturers to develop cleft-specific algorithms and hardware improvements (e.g., smaller scanner tips) are needed.

Conclusion

This study highlights both the potential and the challenges of integrating digital workflows into CLP treatment. While digital impressions offer distinct advantages in precision and efficiency, practical adoption is hindered by educational and financial constraints. To support digital integration, it is recommended that dental curricula include IOS training modules, paired with hands-on workshops and targeted funding initiatives. Future research should focus on the long-term outcomes of digital workflows in enhancing patient care and treatment efficiency.

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Questionnaire

Demographic Details

1. Gender –
2. Age group-
3. Qualification-

Knowledge

1. Have you encountered any cleft lip or cleft palate cases?
   a. Yes
   b. No

2. Are you familiar with the digital impression technique in cleft lip and palate cases?
   a. Yes
   b. No
3. Which all fields of Dentistry deal with cleft lip and palate cases?
   a. Prosthodontics and Crown & Bridge
   b. Periodontology
   c. Conservative dentistry and Endodontics.
   d. Orthodontics & Dentofacial Orthopedics.
   e. Oral Pathology & Microbiology.
   f. Pedodontics & Preventive Dentistry.
   g. Oral Medicine and Radiology.
   h. Oral and Maxillofacial Surgery
4. Have you received any training or education in digital technology for cleft lip and palate cases?
   a. Yes
   b. No

Attitude

5. Would you like to use a digital tool that can be helpful in planning and treating cleft lip and palate cases?
   a. Yes
   b. No
6. How do you rate the accuracy of digital impressions compared to conventional impressions for cleft lip and palate cases?
   a. Superior
   b. Inferior
   c. Comparable
7. Do you think that digital impression is more cost-effective compared to conventional impressions for cleft lip and palate cases?
   a. Yes
   b. No
8. Have you found that digital tools have improved communication with patients and other healthcare providers in cleft lip and palate cases?
   a. Yes
   b. No
9. Do you think that digital tools increase efficiency in your workflow for cleft lip and palate cases?
   a. Yes
   b. No
10. Have you noticed any differences in the time required for follow-up appointments or adjustments when using digital impressions compared to conventional impressions for cleft lip and palate cases?
    a. Yes
    b. No
11. Would you recommend your fellow practitioners implement digital workflow in treatment procedures for cleft lip and palate cases?
    a. Yes
    b. No

Practice

12. Which impression technique do you employ while treating cleft lip and palate case?
    a. Conventional alginate impression
    b. Digital impression
13. Have you ever used digital impressions for cleft lip and palate cases?
    a. Yes
    b. No
14. What factors do you consider when deciding whether to use digital impressions or conventional impressions for cleft lip and palate cases?
    a. Patient comfort
    b. Cost
    c. Time

d. infrastructure
e. Accuracy

15. Have you encountered any challenges when using digital tools in cleft lip and palate cases?
    a. Yes
    b. No
16. If yes, what were they?
    a. Uncooperative patient
    b. Depth of field
    c. Size of intraoral scanner
    d. Time required
    e. Accuracy
17. What improvements or advancements in digital impression technology do you think would be beneficial for cleft lip and palate cases specifically?