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CLINICAL ARTICLE

Randomized controlled pilot study assessing efficacy, efficiency, and patient-reported outcomes measures of chairside and labside single-tooth restorations

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Abstract

Objectives: To test whether or not a chairside workflow (CHAIR) is similar to a labside workflow (LAB) in terms of efficacy (primary outcome) and efficiency (secondary outcome).

Material and methods: Eighteen subjects in need of a single-tooth restoration in the posterior region of the maxilla or mandible were consecutively recruited and randomly assigned to the CHAIR or LAB workflow. Patient-reported outcome measures (PROMs; efficacy) were assessed using a questionnaire with visual analog scale. The white Æsthetic score (WES) was applied to evaluate the Æsthetic outcome objectively. The clinical and laboratory time (efficiency) were recorded. Nonparametric methods were applied for the group comparisons.

Results: The overall median Æsthetic evaluation after treatment was 10 (interquartile range = IQR: 9.5–10) in group CHAIR and 10 (IQR: 9.5–10) in-group LAB (Mann–Whitney [MW] test $p = 1.000$). The WES amounted to 4 (IQR: 3–5) (CHAIR) and to 8 (IQR: 7–9) (LAB) (MW test $p < 0.0001$). The median total working time for the clinician in-group CHAIR was 49.9 min. (IQR: 40.9–63.7) and 41.4 min. (IQR: 37.2–58.2) in-group LAB (MW test $p = 0.387$).

Conclusions: Subjective PROMs of single-tooth supported restorations fabricated in a CHAIR or LAB workflow led to similar scores of patients' satisfaction and a moderate negative correlation for the objective evaluation of the clinician in the LAB workflow.

Clinical significance: PROMs can be considered a key element in the decision-making process for restoring single-tooth restorations. The patients' perception of Æsthetics was similar for the CHAIR or LAB workflows. The additional efforts undertaken with the LAB workflow did not result in a patient benefit when compared to a CHAIR workflow.

KEYWORDS
chairside, digital workflow, labside, patient-reported outcomes, single-tooth restorations

1 | INTRODUCTION

Fully digital workflows in restorative dentistry are based on computer-aided design and computer-aided manufacturing (CAD/CAM) processes. These technologies thereby offer a wide range of benefits for patients and clinicians. This is based on data reporting the fully digital workflow to be more efficient, since time-consuming manual steps can be reduced compared to conventional impression and fabrication techniques.[1,2] Consequently, the digital approach has been considered an alternative to conventional restorative approaches for fixed dental prostheses (FDPs).[3]

Two options exist to treat patients in need of a single-tooth restoration applying a digital workflow: in office systems (chairside fabrication of the restoration by the dentist) and lab-based systems (labside fabrication of the restoration by a dental technician/milling center).[1]

In the LAB workflow, the digital impression is sent to a dental laboratory. The dental technician uses a CAD software to design the reconstruction. The restoration is then milled with a CAM system in the dental laboratory or by a centralized milling center. During the second appointment in the dental practice, the restoration will be usually inserted.[3] The LAB process is well-documented and demonstrated to result in favorable long-term outcomes of the restorations.[4]

In the CHAIR workflow, an indirect restoration is designed and fabricated in the dental practice and delivered in one single appointment.[5–7] The CHAIR workflow has a long history in restorative dentistry with initial indications ranging from inlays to onlays. Later on, the extent of the restoration (veneers, full crowns, implant-borne crowns) as well as the number of restorations being fabricated simultaneously increased. Reported data on the CHAIR workflow demonstrate favorable clinical outcomes with survival rates ranging between 94.6% and 96.3% after 4 years[6,8] and 83.5% and 95% after 10 years.[7,9]

Critical parameters in the decision-making process for either one of the two workflows include scientific clinical data, costs, efficacy and efficiency.

Both digital workflows have been extensively described in the literature with a focus on objective criteria (e.g., survival rates, accuracy of the restorations). From a patient's perspective, comparative data on patient-reported outcome measures (efficacy and efficiency) are considered to be a key element in the decision-making process for either one of the two workflows.

Consequently, the aim of the present pilot randomized controlled clinical trial was to test whether or not a CHAIR workflow is similar to a LAB workflow in terms of efficacy (primary outcome) and efficiency (secondary outcome).

2 | MATERIAL AND METHODS

2.1 | Study design and population

The present study was designed as randomized controlled pilot study, comparing a chairside to a labside workflow for the fabrication of single-tooth restorations in the molar region based on questionnaires and clinical examinations. The clinical trial was performed based on the guidelines of the Helsinki declaration and approved by the local ethics committee of the Canton of Zurich, Switzerland (ref. KEK-ZH_Nr. 2019-02016).

Eighteen subjects in need of a single tooth-borne restoration in the posterior region of the maxilla or mandible were consecutively recruited at the Clinic of Reconstructive Dentistry, Center of Dental Medicine, University of Zurich, Switzerland. All participants hat to fulfill the following inclusion criteria:

- ≥ 18 years of age
- Need for a single tooth-borne crown in the premolar and molar zone of the maxilla or mandible (without third molars).
- At least one interproximal contact had to present.
- Presence of antagonists

Patients were excluded from the study in case of the following exclusions criteria:

- Active periodontal disease
- Poor oral hygiene after hygienic phase (Plaque Index > 20%)
- Self-declared pregnancy or breast feeding at the date of inclusion
- Known or suspected non-compliance, drug or alcohol abuse
- Inability to follow the procedures of the study, for example, due to language problems, psychological disorders, dementia, etc. of the participant
- Smoking more than 15 cigarettes a day
- Bruxism

All subjects received all necessary information related to the study protocol and interventions and provided their informed consent prior to the start of the investigation.

2.2 | Clinical and laboratory procedures

The clinicians were similar experienced with both workflows. Before the study initiation, the clinicians attended a training session to review the study protocol, to standardize the clinical procedure and to calibrate the assessments techniques. This meeting was organized by the study monitoring team of the clinic.

2.2.1 | Screening

The eligibility of the patient for the clinical trial was assessed during a screening visit based on the inclusion criteria. Once included, the patients' preferences for both workflows were assessed with a questionnaire. After the initial examination (screening visit) the patient has been randomly allocated to the two treatment groups, so that an equal distribution (1:1) of patients resulted to both treatment groups. The randomization sequence was generated by using a computer-generated list and sealed envelopes. An independent person, not

belonging to the study team, has generated these allocation sequences. Whenever a clinician enrolled a patient for the study, a subject number was assigned to the patient.

2.2.2 | Preparation/impression

The study abutment teeth were prepared following the manufacturer's guidelines for all-ceramic restorations with at least 1.5 millimeters of occlusal reduction. In both digital workflows, an intraoral scanner (Primescan, Software version 5.1.3, DentsplySirona, Bensheim, Germany) was used to record a partial-arch (study site) scan and an occlusal registration (buccal scan) following the manufacturer guidelines. Depending on the randomization the scan was transferred to the dental laboratory via internet (LAB) or the clinician continued with the design of the restoration using a CAD Software (CHAIR).

CHAIR workflow

After virtual designing the restorations in the CAD software (CEREC, Software version 5.1.3, DentsplySirona, Bensheim, Germany) the digital file was sent to an in-house milling machine (CEREC MCXL, DentsplySirona, Bensheim, Germany). The restorations were milled out of a zirconia-reinforced lithium silicate glass–ceramic block (Celtra Duo, DentsplySirona, Bensheim, Germany). After machining, the fixation of the sprue from all the restorations was removed. Subsequently, the restorations were tried in and selective chairside adjustments were performed. When a correct fit was achieved, the restorations were cemented by using a 3-step etch-and-rinse adhesive system and dual-curing resin cement. After removal of excess cement and polishing the restorations were delivered in the same appointment.

LAB workflow

In the labside workflow, one single dental technician performed all the laboratory steps for the fabrication of the monolithic full-contour single-tooth restorations (Celtra Duo, DentsplySirona, Bensheim, Germany). After designing and milling the restorations (inLab SW 19.1; MCX5, DentsplySirona, Bensheim, Germany) were adjusted and prepared for the try-in appointment. At the try-in appointment the clinicians evaluated all the clinical parameters (e.g., contact points, occlusion, color, shape, marginal adaptation, color of the crowns). Subsequently, the restorations were, if necessary, adjusted, then finalized by an individualization and glazing step.

In both workflows the final restorations were adhesively cemented with a 3-step etch-and-rinse adhesive system and dual-curing resin cement and the time for chairside finishing (polishing, removal of cement) was recorded.

The adhesive pretreatment of the dentin was applied following the manufacturer's instructions, using a self-etching primer, adhesive and a bonding agent (Syntact classic and Heliobond; Ivoclar Vivadent, Schaan, Liechtenstein).

For the adhesive placement the restorations were cleaned with a cleaning paste (Ivoclean, Ivoclar, Vivadent, Schaan, Liechtenstein) and a 5% hydrofluoric acid etching gel (IPS ceramic etching gel, Vivadent, Schaan, Liechtenstein) was applied and immediately after the dried and etched internal parts were silanated (MonoBond Plus, Vivadent, Schaan, Liechtenstein) for the adhesive cementing. The restorations were adhesively placed with a dual-curing resin cement (Variolink Aesthetic DC, Vivadent, Schaan, Liechtenstein). After initial light activation, all the excess luting materials was removed and thereafter light-polymerization was applied from the palatal, buccal, occlusal and interproximal side. The occlusal contacts were checked and if needed adjusted. The removal of excess luting materials was completed using different fine-grit bur sizes and polishing paste according the manufacturer's instructions.

The subjects were scheduled 1–2 weeks after cementation for the final examination and patients-reported and clinical outcomes were assessed.

2.3 | Outcome measures

2.3.1 | Patient-reported outcome measures

PROMs were assessed using questionnaires consisting of a visual analog scale (VAS) with anchor terms 0 (low) to 10 (high).

The questionnaire provided prior to the treatment included four questions evaluation the subjective patient's expectations for the treatment. This included the following questions:

(1) How high is your expectation in terms of Æsthetics of the crown?

(2) What is your expectation in terms of the shape of the crown?

(3) What is your expectation in terms of the color of the crown?

(4) What is your expectation in terms of the chewing comfort of the crown?

An additional question assessed the importance of costs relative to Æsthetics on a VAS with anchor terms – 5 (high for costs), 0 (costs and Æsthetics equally important) and 5 (high for Æsthetics):

(5) What is more important to you: the costs or Æsthetics of the crown?

At the final visit, four questions assessed whether or not the patient's expectation had been fulfilled in terms of the same parameters as described above.

1. Were your expectations in terms of Æsthetics of the crown fulfilled?
2. Where your expectations in terms of the shape of the crown fulfilled?
3. Where your expectations in terms of the color of the crown fulfilled?
4. Where your expectations in terms of the chewing comfort of the crown fulfilled?

2.3.2 | Æsthetic outcomes (WES)

The clinician's perspective of the restoration Æsthetic was assessed with the white Æsthetic score index WES[10] evaluating the Æsthetic appearance. After delivery of the restorations one clinician who was

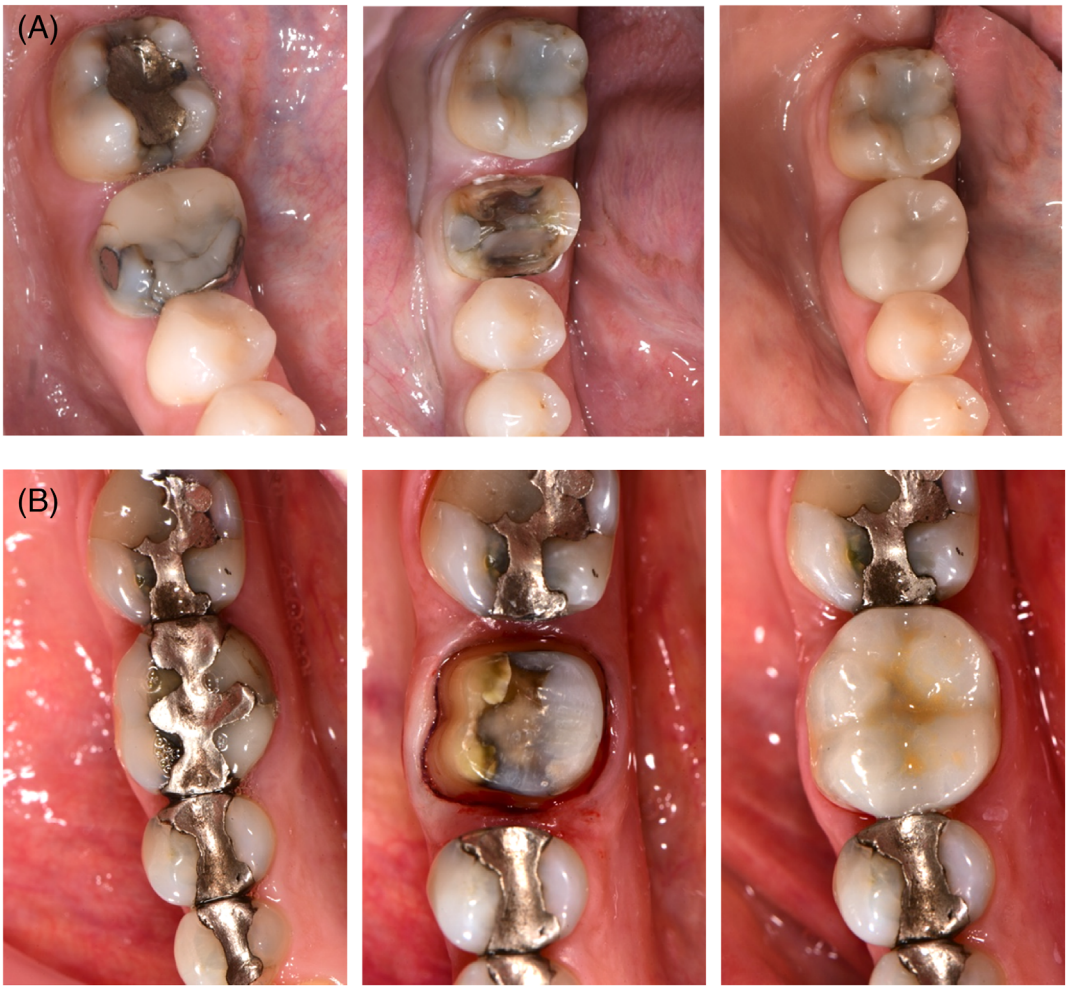

FIGURE 1 (A) Single-tooth crown 46 restored in the CHAIR workflow. (B) Single-tooth crown 46 restored in the LAB workflow

not involved in the treatment of the patients, was asked to assess the Æsthetic of the restorations. The occlusal and side view of each restoration was shown on the computer (Keynote, Version 11.0, Apple Inc., Cupertino, California U.S.). A clinician, not involved in the study was asked to rate the Æsthetic appearance using the WES index. The evaluation comprised 5 subgroups: tooth form, tooth volume, color, surface textures and translucency. The highest WES score in each subgroup was 10, which indicates closest match of the clinical single-tooth restorations with the neighboring teeth. For the correlation between the subjective patient-reported outcome measures (VAS Æsthetic scores after treatment) for the CHAIR and LAB and clinician's Æsthetic satisfaction (WES total scores) was calculated.

2.3.3 | Clinical and laboratory time recording

The following manufacturing and clinical steps were recorded in both workflows (in min): Impression taking, CAD of the restoration, chairside adjustment time, chairside finishing time.

In the CHAIR workflow the time for the clinician to design the restoration with the CAD software, the chairside adjustment time and finishing time were recorded.

And in the LAB workflow the time needed to design the restoration with the CAD software as well as adjustments of the restorations in the laboratory was documented. Thereafter, the chairside adjustment time, if necessary, as well as the finishing time after cementation were recorded.

2.3.4 | Technical outcomes

For the final restoration examination two independent evaluators performed all outcome measures by using the modified United States Public Health Service (USPHS,[11]) criteria. In the event of disagreement in the assessment of a criterion, the evaluators reached agreement in discussing the discrepancy. Alfa was given when there was an ideal clinical situation presented and no need of adjustments was necessary. Bravo (B) was rated when minor mismatches in color, shade, anatomical form and increased

TABLE 1 Patient-reported outcome measures (PROMs) for Æsthetics, shape, color, chewing comfort and the relationship between costs and Æsthetics (VAS, %) prior to (P) and after the prosthodontic treatment (D)

	CHAIR (P)	LAB (P)	*p-value HL CL*	CHAIR (D)	LAB (D)	*p-value HL CL*
Æsthetics						
n	9	9	*1.000*	9	9	*1.000*
Median VAS	8	8	*0*	10	10	*0*
IQR: Q1-Q3	3.5–9.5	6–9	*(−4, 2)*	9.5–10	9.5–10	*(0,0)*
Shape						
n	9	9	*0.941*	9	9	*0.735*
Median VAS	9	9	*0*	10	10	*0*
IQR: Q1-Q3	3.5–9.5	6.5–9	*(−4, 2)*	9.5–10	10–10	*(0, 0)*
Color						
n	9	9	*0.559*	9	9	*0.359*
Median VAS	8	8	*0*	10	10	*0*
IQR: Q1-Q3	3.5–9	7–9.5	*(−4, 1)*	7–10	9.5–10	*(−3, 0)*
Chewing function						
n	9	9	*0.620*	9	9	*0.471*
Median VAS	10	10	*0*	10	10	*0*
IQR: Q1-Q3	9–10	9.5–10	*(−1, 1)*	9.5–10	10–10	*(0, 0)*
Relation cost-Æsthetics						
n	9	9	*0.050*			
Median VAS	0	0	*0*			
IQR: Q1-Q3	−3.5–0	0–3	*(−5, 0)*			

Note: HL, Hodges-Lehmann estimate for the group difference with its 95% confidence interval (CL).

occlusal contacts occurred. These mismatches were, however, still clinical acceptable and needed no further treatment. Charlie (C) or Delta (D) respectively when the restorations had to be redone because they clinically unacceptable.

2.4 | Statistical analysis

Descriptive statistics were computed for all the variables with software SAS 9.4 (SAS Institute Inc., Cary, North Carolina, U.S.). Results are presented as medians and interquartile ranges (Q1-Q3) for continuous variables and as frequency tables for qualitative variables. Group comparisons were based on the nonparametric Wilcoxon-Mann-Whitey (MW) test for continuous variables (because of the small samples and the ordinal variables) and the Chi-squares test for categorical ones. Nonparametric Hodges-Lehmann (HL) estimates for the group differences together with its 95% confidence interval are derived for the continuous variable. Pearson or Spearman correlation coefficients were used for association between continuous variables. Results were considered significant at the 5% level (two-sided $p < 0.05$). No correction for the multiple testing of several variables is applied.

3 | RESULTS

Eighteen patients (10 women and 8 men) with a total of 18 posterior single-tooth CAD/CAM restorations participated in the present study. This included two maxillary molars, 12 mandibular molars and four mandibular premolars. All patients were assigned at random to the CHAIR group and the LAB group (Figure 1).

3.1 | Patient-reported outcome measures

All results for PROMs according to Æsthetics, shape, color, chewing comfort and the relationship between costs and Æsthetics prior to and after the prosthodontic treatment are displayed in detail in Table 1 and Figure 2. Hodges-Lehmann estimate with the 95% confidence intervals are given in the tables.

Related to patients' perceptions the median VAS score for Æsthetics was 8 (IQR: 3.5–9.5) prior to and 10 (IQR: 9.5–10) after treatment for the CHAIR group as well as 8 (IQR: 6–9) and 10 (IQR: 9.5–10) for the LAB group (intergroup [MW test] $p = 1.000/1.000$).

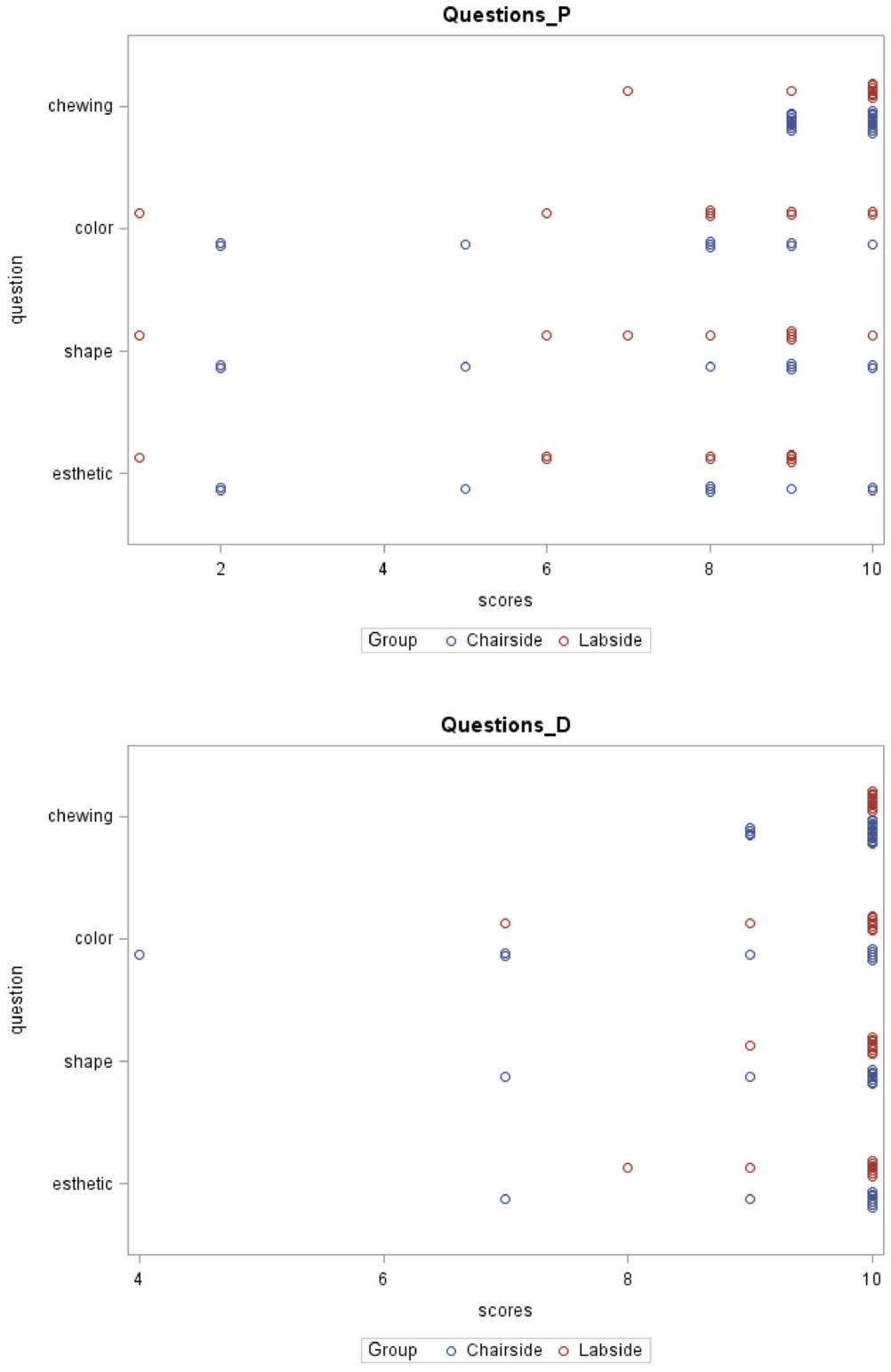

FIGURE 2 Scatterplots for patient-reported outcome measures (VAS) according to Æsthetic, shape, color, chewing function for both groups (CHAIR, LAB) prior treatment (P) and after treatment (D)

The respective median VAS score for anatomical shape of the tooth amounted to 9 (IQR: 3.5–9.5) (prior to treatment) and to 10 (IQR: 9.5–10) (post treatment) for the CHAIR group as well as to 9 (IQR: 6.5–9) and to 10 (IQR: 10–10) for the LAB group (intergroup $p = 0.941/0.735$).

The median VAS score for color match was 8 (IQR: 3.5–9) prior to and 10 (IQR: 7–10) after treatment for the CHAIR group as well as 8 (IQR: 7–9.5) and 10 (IQR: 9.5–10) for the LAB group (intergroup $p = 0.559/0.359$).

TABLE 2 WES scores of the clinicians' Æsthetic satisfaction

Group	Tooth form	Tooth volume/outline	Color	Surface texture	Transluvency	Total score Æsthetic
CHAIR	1	2	0	1	0	**5**
CHAIR	2	1	1	0	0	**4**
CHAIR	1	1	1	0	0	**3**
CHAIR	1	2	1	1	0	**5**
CHAIR	2	2	1	0	0	**5**
CHAIR	1	1	0	1	0	**3**
CHAIR	1	1	1	0	0	**3**
CHAIR	2	1	0	0	0	**3**
CHAIR	1	2	1	1	0	**5**
LAB	2	2	1	2	2	**9**
LAB	1	2	1	2	2	**7**
LAB	2	2	1	2	2	**9**
LAB	1	2	1	1	2	**7**
LAB	1	2	1	2	2	**8**
LAB	1	2	1	2	2	**8**
LAB	2	2	1	2	1	**8**
LAB	1	2	1	2	1	**7**
LAB	2	1	2	2	2	**9**

TABLE 3 Time measurement (in minutes) for CHAIR and LAB group

	Design (min.)	Chairside adjustments (min.)	Finishing/Polishing (min.)	Total time (min.)
CHAIR	5.12 (3.04/7.96)	7.3 (5.74/7.37)	16.52 (8.85/21.44)	49.89 (40.56/63.74)
LAB	13 (10.5/14.5)	0 (0/2.5)	7 (3.5/12.53)	41.42 (33.29/58.17)
p values	<0.001	0.003	0.018	0.387
HL/CL	−6.91 (−9.91, −4.42)	6.63 (3.75, 7.33)	8 (1.12, 15.52)	8.47 (−4.34, 23.4)

Note: HL, Hodges-Lehmann estimate for the group difference with its 95% confidence interval (CL).

The median VAS score for chewing comfort was 10 (IQR: 9–10) prior to and 10 (IQR: 9.5–10) after treatment for the CHAIR group as well as 10 (IQR: 9.5–10) and 10 (IQR: 10–10) for the LAB group (intergroup $p = 0.620/0.471$).

The median VAS score for the importance of costs relative to Æsthetics revealed no significance (intergroup $p = 0.050$) between the two groups 0 (IQR: −3.5-0) for the CHAIR group; 0 (IQR: 0–3) for the LAB group).

VAS scores for Æsthetics, tooth shape, color match and chewing comfort showed an improvement within both groups (CHAIR and LAB) without reaching a statistical significance. The scores pre- and post-treatment for the ratio Æsthetics-cost reached no statistical significance (Figure 2).

The VAS scores for Æsthetics, tooth shape, color match and chewing comfort between CHAIR and LAB compared to baseline, showed statistically significant changes for Æsthetics ($p = 0.023$ for CHAIR and $p = 0.031$ for LAB group) and for tooth shape ($p = 0.031$ for CHAIR and $p = 0.016$ for LAB group).

3.2 | Æsthetic outcome (WES)

The clinicians' objective Æsthetic assessment according the WES index after delivery of the restorations is shown in Table 2. The median WES scores for Æsthetics rated by the clinician for the was 4 (IQR: 3–5) for the CHAIR group and for 8 (IQR: 7–9) (intergroup $p < 0.001$ for the LAB group.

The Spearman test revealed a moderate negative (−0.73) and significant ($p = 0.025$) correlation between the clinicians' and patients' satisfaction in the CHAIR group. In the LAB group, a trend towards a positive non-significant correlation (0.43) between the clinicians' and patients' Æsthetic satisfaction was found ($p = 0.244$).

3.3 | Treatment time

All results for the time measurement are displayed in Table 3. The median time for the virtual design of the restorations ranged from

TABLE 4 The modified US Public Health Service (USPHS) criteria for assessing single-teeth restorations

Category/rating	Alfa A (%)	Bravo B (%)	Charlie C (%)	Delta D (%)
Fracture	CHAIR 9 (100%) LAB 9 (100%)			-
Occlusal wear	CHAIR 8 (88.8%) LAB 9 (100%)	CHAIR 1 (11.1%)		-
Marginal adaptation	CHAIR 6 (%) LAB 8 (88.8%)	CHAIR 3 (%) LAB (1 (11.1%)		-
Anatomic form	CHAIR 9 (100%) LAB 8 (88.8%)	LAB (1 (11.1%)		-
Radiograph	CHAIR 9 (100%) LAB 9 (100%)			-
Patient satisfaction	CHAIR 9 (100%) LAB 9 (100%)			

5.1 min (IQR: 3.0–8.0) in the CHAIR workflow to 13.0 min (IQR: 10.5–14.5) for the LAB workflow (intergroup $p = 0.000$).

When the restorations were delivered, the time needed for chairside adjustments ranged between 7.3 min (IQR: 5.7–7.4) in the CHAIR workflow and 0.0 min (IQR: 0–2.5) in the LAB workflow. The chairside adjustment time was statistically significant in favor of the labside group (intergroup $p = 0.003$).

The time to finish/polish the restorations after cementation ranged between 16.5 min (IQR: 8.9–21.4) for the CHAIR workflow and 7.0 min (IQR: 3.5–12.5) for LAB workflow. The clinicians invested significantly less time for the finish and polish the labside restorations compared to the chairside restorations (intergroup $p = 0.018$).

The overall treatment time, meaning taking every manufacturing step of both workflows into account, the total active working time for the clinician in the clinical ranged between 49.89 min (IQR: 40.6–63.7) (CHAIR) and 41.42 min (IQR: 37.3–58.2) (LAB) (intergroup $p = 0.387$).

3.4 | Clinical examination (USPHS)

All data recorded according to USPHS criteria are displayed in Table 4. All restorations were rated alfa for all parameters, except for two labside restorations being rated bravo (one restoration for anatomic form, one restoration marginal adaptation).

4 | DISCUSSION

The present RCT assessing efficacy (patient-reported outcome measures), time efficiency and clinical outcomes of single-tooth restorations fabricated in a CHAIR or LAB workflow predominantly revealed: (i) the subjective patients' assessment of Æsthetics post treatment to be independent of the applied workflow; (ii) that the additional efforts undertaken in the labside workflow did not result in higher PROMs compared to a chairside workflow; (iii) a similar overall chairside time for both workflows and, (iv) similar clinical outcomes according to modified USPHS criteria for both workflows.

Indirect restorations in the posterior zone are indicated to maintain and/or improve chewing function and Æsthetics. Functional aspects and technical outcomes of posterior single-tooth restorations are well-documented and can objectively be assessed applying a plethora of outcomes measures.[10,12,13] Whereas clinical studies focused in the past on objective criteria and indices to evaluate Æsthetics of single-tooth restorations,[14] data on subjective parameters (e.g., PROMs) are scarce.[15] Moreover, it has been recommended to include PROMs as a routine method of assessment in clinical studies.[14,16–19] The outcomes of the present study with a primary focus on PROMs demonstrated similar Æsthetic outcomes for the two applied workflows. Specifically, the patient's perception of Æsthetics evaluated after treatment amounted to a score of 10 on the VAS in both workflows. These findings are in line with a study comparing the Æsthetic outcome of posterior single-implant restorations using two different workflows.[3] In that study patients evaluated Æsthetics of posterior restorations with or without additional veneering. The respective median VAS score was 8.2 versus 9.0. In addition, the overall satisfaction in terms of Æsthetic outcomes was high in both groups and the extra effort of veneering did not result in higher PROMs.

Several possibilities exist to fabricate single-tooth restorations in the posterior zone. In general, the LAB workflow is considered the gold standard for posterior single-tooth restorations. It traditionally involves impression taking, design and laboratory manual steps. In order to improve the fabrication process, more modern concepts applying digital technologies aim at reducing for example the chairside and laboratory time, the number of clinical appointments and costs (fabrication of monolithic restoration instead of veneered restauration) for the benefit of the patient ([1,2,5]). In the present study, the number of appointments needed differed between the two workflows (CHAIR: 1; LAB 3).

The additional efforts undertaken in the LAB workflow did not result in more favorable PROMs. This to some extent, might come as a surprise, having included a highly skilled dental technician. It does, however, confirm data of previous studies, demonstrating that the patient's perception of Æsthetics is lower and the patient's acceptance higher than the ones of professionals and dental technicians ([17,20,21]). In contrary, professionals and dental technician perceive

color differences to a higher extent. In the present study the restorations were professionally assessed applying objective (WES) and subjective criteria (VAS). It was demonstrated that the Æsthetic outcomes differed within both workflows in favor of group LAB. Clinicians were more critical though than patients, when assessing the Æsthetic outcome. This resulted in in a moderate correlation with a statistical significance in the CHAIR group. The negative association can be explained by the fact that clinicians deal with Æsthetic assessments on a daily basis and are trained to apply standardized parameters, whereas patients evaluate the Æsthetic appearance with their own subjective parameters. In contrast, the LAB group demonstrated a positive trend reaching a statistical significance. The clinicians' Æsthetic satisfaction was therefore similar to the patients' satisfaction. Two further appointment (for the LAB group) did not offer more favorable Æsthetics compared to the CHAIR workflow from a patient's perspective.

Other parameters might therefore be considered in the decision-making for a specific treatment option. This includes financial aspects as well as chairside time. The CHAIR workflow is associated with higher investment costs (e.g., milling machine) for the professional, but lower treatment costs for the patient. In the LAB workflow, these investments are made by the dental laboratory and can therefore be outsourced from the clinic.

The LAB workflow required three times the number of appointments compared to the CHAIR workflow. Interestingly, when calculating the active chairside time, the differences between the two workflows were negligible (CHAIR: 49.9 min.; LAB: 41.4 min.). This included, in the group CHAIR, the design and milling of the restoration as well as some time needed for adjustments (i.e. occlusion, contact points). In the LAB workflow, the active chairside time was lower since the entire fabrication process of the restoration was outsourced and the time for adjustments was substantially lower.

The outcomes of the present clinical study and its generalization are to some extent limited by (i) the study design being a pilot investigation with a rather low sample size due to the lack of previous clinical data and, (ii) the lack of split-mouth design that did not allow intergroup comparisons within the same patient.

5 | CONCLUSIONS

The present study demonstrated similar and high PROMs when single teeth were restored by a chairside or a labside workflow. The additional efforts undertaken in the labside workflow did not result in more favorable PROMs, but in less chairside time for the clinicians and a higher WES score.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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