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Original Article

Polycaprolactone versus calcium hydroxylapatite injectable treatments in the T-zone for facial rejuvenation: a clinical comparative study

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Abstract: Objective: This analysis, being a retrospective study, set out to compare the effect of polycaprolactone (PCL) versus calcium hydroxylapatite (CaHA) in injectable T-zone rejuvenation. Methods: A total of 147 patients receiving facial T-zone rejuvenation with injectables at our center constituted the research cohort. Inter-group assessments (PCL group with 72 cases vs. CaHA group with 75 cases) were conducted from the dimensions of curative efficacy, dynamic nasion displacement, physician-assessed tactile perception of hardness score, nasofrontal angle, effect maintenance duration, treatment interval, facial skin laxity status, facial aesthetic score, serum growth factors, and patient satisfaction. Results: As compared to the PCL group, the CaHA group (1) showed an evidently higher excellent-and-good rate and superior patient satisfaction; (2) demonstrated lower dynamic nasion displacement, nasofrontal angle, and facial skin laxity-associated indices (except the interzygomatic distance) post-operation; (3) exhibited statistically higher post-treatment physician-assessed tactile perception of hardness scores, nasofrontal angle target achievement rate, longer effect maintenance duration, better maintenance of the radix height and chin projection at 12 months, extended treatment intervals, as well as higher aesthetic scores and VEGF and bFGF levels. No significant inter-group difference in the total adverse reactions was identified. Conclusion: CaHA is clinically advantageous over PCL in injectable T-zone rejuvenation.

Keywords: Polycaprolactone, calcium hydroxylapatite (CaHA), facial T-zone, rejuvenation, clinical comparative study

Introduction

Skin represents the largest organ of the human body. Skin aging, a dynamic and complicated process, involves the secondary structural changes of the skin, underlying muscles, subcutaneous adipose tissue, and skeletal structure [1]. Skin aging covers internal and external aging; the former is related to continuous oxidative damage caused by multiple factors, with reactive oxygen species-related oxidative stress being the representative event, while the latter is associated with persistent exposure to ultraviolet, smoking, high temperature, and air pollution [2, 3]. Presently, the public shows an ever-growing pursuit of skin health and beauty, evidenced by a projectedly increased annual worldwide expenditure on facial rejuvenation from $24.6 billion to about $44.5 billion in 2030 [4]. Facial rejuvenation, performed surgically or non-surgically to repair the damaged skin to tighten or eliminate saggy tissue, enables a more natural and harmonious effect by individualizing treatment strategies [5]. Surgical treatment, like a facelift and autologous fat graft, can correct aging-related structural changes through anatomical means to realize facial rejuvenation [6]. Non-surgical interventions (injection, energy therapy, etc.), being increasingly popular, can provide reversible or short-term effects compared with surgery [7]. This study mainly analyzes the clinical efficacy of facial T-zone rejuvenation with injectables of different regenerative materials.

In facial rejuvenation, the T-zone, consisting of the forehead, glabella, and chin, is the basic skeleton of the face and the key anatomical structure to create facial three-dimensionality and contour aesthetics [8]. Bone absorption and soft tissue drooping in the T-zone will weaken facial three-dimensionality. Bone remodeling with injectable fillers in the T-zone can not only restore its structural support, but also ameliorate the sagging of surrounding tissues, thus realizing overall facial rejuvenation [9]. As a bioabsorbable biostimulating polymer, polycaprolactone (PCL) shows the clinical strengths of immediate tissue support and long-term collagen stimulation in non-surgical facial rejuvenation [10]. It can be used as a collagen stimulator to effectively stimulate collagen fiber formation in subcutaneous adipose tissue, positively impacting the rejuvenation of subcutaneous adipose tissue and the improvement of skin volume and elasticity [11]. Like PCL, calcium hydroxylapatite (CaHA) is also a renewable material and a commonly used minimally-invasive skin filler that can relieve skin aging [12]. CaHA has been indicated to promote skin regeneration, fullness, and contour shaping through various mechanisms, such as increasing adenosine triphosphate (ATP) concentrations in human skin fibroblasts and promoting cell proliferation, thus realizing skin regeneration; by up-regulating the expression of procollagen genes, it facilitates collagen generation [13].

Few investigations have so far focused on the comparative efficacy of PCL versus CaHA in injectable T-zone rejuvenation. By conducting a clinical comparative analysis, this study explores non-surgical T-zone rejuvenation approaches that people can derive greater benefits from, aiming at providing patients with better treatment options.

Clinical data

General information

This study selected 147 patients receiving facial T-zone rejuvenation with injectable fillers in our center (selection time: February 2024-February 2026), and divided them into a PCL group (n=72) and a CaHA group (n=75) according to the different materials they used. The balanced baseline data distribution ensured clinical comparability of the study cohorts ($P > 0.05$). This study was approved by the ethics committee of Sichuan Yuehao Medical Aesthetics Hospital.

Eligibility criteria

Those eligible met all of the following criteria: in line with the relevant standards stipulated in the Expert Consensus on Facial Rejuvenation Treatment in the Chinese Population [14]; requirements for facial wrinkle removal, skin tightening enhancement, and facial beauty improvement; naive to facial rejuvenation; irregular and unsmooth facial contour; age: 22-60; and clinical data completeness.

Exclusion was based on the fulfillment of any of the grounds stated below: recent (3 months) filler treatment or phototherapy/electrotherapy; co-existing facial wounds or infections; history of facial surgery or facial burns; pregnant or lactating status; concurrent chronic diseases (e.g., hypertension, diabetes, coronary heart disease); facial cosmetic treatment in recent 3 months; coagulation dysfunction, immune system diseases, or serious basic diseases; malignant tumor; mental disorders; long-term smokers; or allergic constitution.

Treatments

All patients received comprehensive facial T-zone contouring with injectables, covering the forehead (the glabella and the median frontal sulcus), nose (root, dorsum nasi, tip, and columella), and chin (pogonion and chin contour). The PCL group used Ellansé® (PCL microsphere filler), with each vial containing 150 mg of PCL microspheres suspended in a sodium carboxymethylcellulose (CMC) hydrogel carrier. In the CaHA group, Aphranel® (CaHA filler, 0.5 ml per vial) was used, which was a ready-to-use sterile gel requiring no re-dissolution. The injection technique was slightly adjusted, given the difference in rheological properties between the two materials. All operations were completed by the same senior physician with over 5 years of experience in injection cosmetology, using standardized operation flows: during injection, the speed was controlled at 0.1-0.2 mL/s, with low-pressure push injection (to ensure stable and consistent output and thus uniform diffusion of the material), unified supraperiosteal or subcutaneous injection plane, and a 30-90° injection angle. The principles of asepsis were strictly followed.

Forehead and glabella area: The fanning technique with a blunt-tip cannula for supraperiosteal injection was adopted in the PCL group, with 0.1-0.2 mL per point and a total amount of 0.3-0.5 mL. In the CaHA group, supraperiosteal infiltration was also performed. However, due to the higher elastic modulus (G' value) of CaHA, precision targeted injection of the periosteal layer was emphasized to give full play to the material's structural support advantage. The injection amount per point, as well as the total amount, mirrored that of the PCL group.

Nose: Both groups used a combination of supraperiosteal point injection using a sharp needle and tunnel injection with a blunt-tip cannula in the nasal dorsum. The nasal root and dorsum were injected with 0.05-0.1 mL at each point in the periosteum layer; for the nasal tip and columella, 0.1-0.2 mL was injected in the subcutaneous layer. The total amount used for the unilateral nasal area was strictly controlled at 0.3-0.6 mL to avoid vascular complications to the greatest extent.

Chin: For both groups, the supraperiosteal point injection using a sharp needle supplemented by the fanning technique with a blunt-tip cannula were employed, focusing on strengthening the connection between the pogonion and mandibular contour, with a total amount of about 0.5-1.0 mL.

Postoperative management: Post-injection, a gentle massage was immediately performed to shape the area, ensuring that the material was evenly distributed. Patients in the PCL group followed the "5-5-5" massage rule (5 times a day, 5 minutes each time, for 5 consecutive days) to promote uniform material distribution and reduce nodular formation. In the CaHA group, only gentle pressing for contouring was carried out without special massage.

Outcome measures

Therapeutic effectiveness. Efficacy was recorded for comparison. The evaluation, completed independently by two doctors who did not participate in the treatment (blind evaluation), followed the Global Aesthetic Improvement Scale (GAIS), combined with the preset treatment target photos for comprehensive judgment [15]: Excellent: The patient's skin was plump and smooth at 1 week post-operation, with no complications and a GAIS score (3 points) reaching the level of "significant improvement" or "great improvement"; Good: The skin was smooth, with no complications and a GAIS score of 2 points (i.e. moderate improvement); Fair: The skin was basically smooth, with a GAIS score (1 point) falling into the category of "slight improvement" or "no change"; Poor: The skin condition showed no obvious change, with poor facial morphology and a GAIS score of 0 or less, which is unacceptable for patients. Before the formal evaluation, the two doctors were trained in the use of the scale. The consistency of the evaluation results was further assessed, which revealed an interclass correlation coefficient (ICC) >0.8, indicating good consistency. The excellent-and-good rate refers to the proportion of the total number of cases that are either excellent or good among all the cases.

Supportive strength and moldability. Supportive strength was evaluated by patient's dynamic nasion displacement and physician-assessed tactile perception of hardness score, while moldability was assessed by nasofrontal angle (NFA) and NFA target achievement rate. Dynamic nasion displacement: Patients' facial images were collected using the three-dimensional photogrammetry system. The displacement distance of the soft tissue nasion during dynamic expressions before and one month after the operation was comparatively evaluated. During the measurement, the patient was told to frown as much as possible to make the muscles between the eyebrows contract completely. This process was completed under the conditions of standardized lighting and fixed head position. A smaller displacement distance and a greater NFA improvement indicate better supportive strength and moldability of the material. Physician-assessed skin tactile perception of hardness score: A five-point Likert scale was used to score the tactile perception of hardness of the injection area of the patient one month post-operation (1 point: extremely soft, like uninjected soft tissue; 2 points: slightly elastic with mild resistance; 3 points: moderate elasticity, similar to the sensation of touching cartilage; 4: obviously hard, with a sensation similar to touching bones; 5: extremely hard, with a sensation that feels like touching the actual bone cortex). Three senior physicians who did not participate in the treatment palpated the patient's T-zone (nasal root, dorsum nasi, and chin) in a double-blind manner, with the mean taken as the final result.

Moldability, evaluated by measuring preoperative and postoperative (1- and 12-month) NFA as well as its target achievement rate, was comparatively analyzed. NFA measurements were semi-automatically calibrated in three-dimensional images based on clear anatomical landmark points (glabella, nasion, apex nasi). The target achievement rate was the proportion of patients whose NFA reached the aesthetic ideal range (115°-130°).

Maintenance duration. The effect maintenance duration, namely the time interval from the date of injection to the significant decline of curative effect (a >50 loss of initial improvement co-judged by both the researcher/ patient), and the treatment interval, defined as the time interval from the first injection to the patient receiving complementary treatment at the same site due to the decline of curative effects, were recorded.

Facial skin laxity. Before and one week after the operation, a digital camera with an 80 mm lens (Konka) was used to take facial photos of both patient groups. Changes in major facial parts were measured by Angel Digital Imaging Studio 3.0 software, including the distance from the pupil to the intersection of the nasolabial fold (NLF) and the vertical pupil line (Pupil-NLF intersection distance), interzygomatic distance, and curvature of arc ABC (A, B, and C represent the angles formed by the intersection points between the nasal base line, the oral commissure line, the pupil vertical line, and the mandibular contour, respectively).

Subjective/objective facial aesthetic score. Patients' aesthetic scores were compared before and 1 week following the operation. A self-made aesthetic rating scale, covering subjective and objective dimensions (0-50 points/ dimension), was used for assessment. A better aesthetic effect was indicated by a greater score. The scale shows high reliability, evidenced by a content validity index of 0.868 and a Cronbach's alpha coefficient of 0.742.

Serum growth factors. Prior to and one week following treatment, all patients provided early-morning venous blood sampling (5 mL) on an empty stomach, with the serum separated to quantify vascular endothelial growth factor (VEGF) and basic fibroblast growth factor (bFGF) levels using enzyme-linked immunosorbent assays (ELISAs). The corresponding human ELISA kits were ordered from AbbKine Scientific Co., Ltd. (KTE6033, KTE3146-3). The detection range of both kits was 31.25-2000 pg/mL, with the limit of detection being 14 pg/mL for the human VEGF ELISA kit and 2.34 ng/mL for the human bFGF ELISA kit. The performance requirement for ELISA quantitative detection was met, evidenced by an intra-batch coefficient of variation (CV) below 10% and an inter-batch CV below 12%.

Safety. The number of cases and the corresponding proportion of adverse events, like bruising, swelling, and subcutaneous nodules, were recorded.

Patient satisfaction. A patient satisfaction investigation was conducted using a self-made 100-point satisfaction survey questionnaire. The domains assessed involved surgical effect, surgical safety, and services. Based on the scores, satisfaction was evaluated as highly satisfied (≥90 points), moderately satisfied (60-89 points), or dissatisfied (<60 points). The total satisfaction rate was the sum of the highly and moderately satisfied rates. The questionnaire demonstrates a content validity index of 0.835 and a Cronbach's alpha coefficient of 0.709, which is highly reliable.

Statistical methods

Normality was evaluated by the Shapiro-Wilk test. This study described measurement data as the mean ± standard deviation (SD) if a normal distribution was followed, employing the independent sample t test to examine between-group differences and the paired t test to identify pre-post-treatment differences. Otherwise, the median (interquartile range) [M(Q1, Q3)] was used for statistical description, and the Mann-Whitney U test was adopted to evaluate between-group differences, with 95% confidence intervals (CIs) of the median differences calculated based on the Hodges-Lehmann estimator. The number of cases/percentage (n/%) was used to represent the counting data, and the comparison between the two groups was made by the X^2 test. Data analysis and processing were executed with SPSS 23.0. A *P*-value <0.05 denotes the presence of statistical significance.

Table 1. Baseline patient data

Items	PCL group (n=72)	CaHA group (n=75)	X^2	P
Sex			0.280	0.597
Male	5 (6.94)	7 (9.33)		
Female	67 (93.06)	68 (90.67)		
Age (years)	35.78±7.14	36.45±7.53	0.553	0.581
Body mass index (kg/m^2)	21.71±2.04	22.04±2.00	0.990	0.324
Nasofrontal angle (°)	132.32±4.57	131.40±4.74	1.197	0.233
Previous botulinum toxin injection history	15 (20.83)	17 (22.67)	0.073	0.788

Note: PCL, polycaprolactone; CaHA, calcium hydroxylapatite.

Table 2. Efficacy comparison

Items	PCL group (n=72)	CaHA group (n=75)	X^2	P
Excellent	25 (34.72)	36 (48.00)		
Good	31 (43.06)	32 (42.67)		
Fair	9 (12.50)	5 (6.67)		
Poor	7 (9.72)	2 (2.67)		
Excellent and good	56 (77.78)	68 (90.67)	4.624	0.032

Note: PCL, polycaprolactone; CaHA, calcium hydroxylapatite.

Results

Patient baseline information

The PCL and CaHA groups showed balanced distributions in gender, age, body mass index (BMI), NFA, and history of botulinum toxin injection (P>0.05; **Table 1**).

Efficacy comparison

Fifty-six cases in the PCL group showed either excellent or good therapeutic effects, compared to 68 cases in the CaHA group. By comparison, the excellent and good rate was statistically better in the CaHA compared to the PCL group (90.67% vs. 77.78%, P=0.032; **Table 2**).

Supportive strength and moldability assessments

The study cohorts differed little in preoperative dynamic nasion displacement (P>0.05). A notable reduction in dynamic nasion displacement was noted across groups at 1 month postoperatively (P<0.01), with a more pronounced decrease in the CaHA group (P<0.001).

The CaHA group also showed higher physician-assessed tactile perception of hardness scores at one month post-operation, with the inter-group median difference (assessed by the Hodges-Lehmann estimator) being -1.000 (95% CI: -1.000, -1.000), demonstrating a statistical difference (Z=-5.749, P<0.001).

The NFA, which was equivalent across the cohorts preoperatively (P>0.05), decreased significantly at 1 month postoperatively (P<0.01) and presented a marginal rise at the 12-month postoperative mark, with the level remaining statistically reduced compared with the preoperative level (P<0.05). The inter-group comparison of NFA revealed a lower NFA in the CaHA group at 1/12 months after the operation (P<0.001; **Table 3**).

Maintenance duration evaluation

The CaHA group showed notably extended effect maintenance duration and treatment intervals than the PCL group (P<0.001; **Table 4**).

Facial skin laxity assessment

The preoperative pupil-NLF intersection distance, interzygomatic distance, and curvature of arc ABC showed no notable between-group disparities (P>0.05). Postoperatively, the pupil-NLF intersection distance and the curvature of arc ABC exhibited a decrease while the interzygomatic distance showed a rise across groups (P<0.05). Through comparison, the CaHA group was found to have a shorter pupil-NLF intersection distance (P<0.01), an equivalent interzygomatic distance (P>0.05), and a lower curvature of arc ABC than the PCL group (P<0.01; **Table 5**).

Facial aesthetic scores

Significant differences were absent in preoperative aesthetic scores, subjective or objective (P>0.05). Both groups showed increased sco-

Table 3. Evaluation of supportive strength and moldability

Items	PCL group (n=72)	CaHA group (n=75)	X^2/Z/t	P
Dynamic nasion displacement (mm)				
Pre-operation	3.03±0.75	2.90±0.69	1.094	0.276
1-month post-operation	1.22±0.47**	0.87±0.31***	5.350	<0.001
Physician-assessed tactile perception of hardness score (points)	3.00 (3.00, 3.00)	4.00 (3.00, 4.00)	-5.749	<0.001
Nasofrontal angle (°)				
Pre-operation	132.00 (129.30, 135.00)	132.00 (128.00, 135.00)	-1.060	0.289
1-month post-operation	126.00 (124.00, 129.80)**	122.00 (120.00, 124.00)***	-5.693	<0.001
12-month post-operation	130.00 (127.30, 131.80)*,&	126.00 (123.00, 129.00)**,&	-4.965	<0.001
1-month postoperative target achievement rate	58 (80.56)	69 (92.00)	4.093	0.043
12-month postoperative target achievement rate	45 (62.50)	61 (81.33)	6.479	0.011

Note: PCL, polycaprolactone; CaHA, calcium hydroxylapatite. *P<0.05, **P<0.01, ***P<0.001, vs. preoperative; &P<0.05, vs. one-month post-operation.

Table 4. Maintenance duration of two groups

Items	PCL group (n=72)	CaHA group (n=75)	X^2	P
Effect maintenance duration (months)	16.61±3.27	19.09±4.37	3.883	<0.001
Treatment interval (months)	14.40±2.49	17.15±3.19	5.810	<0.001

Note: PCL, polycaprolactone; CaHA, calcium hydroxylapatite.

Table 5. Facial skin laxity evaluation

Items	PCL group (n=72)	CaHA group (n=75)	X^2	P
Pupil-NLF intersection distance (cm)				
Pre-operation	8.40±0.47	8.55±0.61	1.665	0.098
Post-operation	8.17±0.47**	7.99±0.34***	2.668	0.009
Interzygomatic distance				
Pre-operation	16.56±0.53	16.60±0.51	0.466	0.642
Post-operation	16.88±0.47***	16.82±0.59*	0.680	0.498
Curvature of arc ABC (°)				
Pre-operation	167.28±18.12	168.95±18.06	0.560	0.577
Post-operation	157.94±14.36***	150.85±15.98***	2.826	0.005

Note: PCL, polycaprolactone; CaHA, calcium hydroxylapatite; NLF, nasolabial fold. *P<0.05, **P<0.01, ***P<0.001, vs. preoperative.

res following the operation (P<0.01), particularly in the CaHA group (P<0.01; **Figure 1**).

Serum growth factor levels

No statistical inter-group significance regarding serum VEGF and bFGF levels was noted before the operation (P>0.05). The levels of both indices were markedly down-regulated post-operation (P<0.01), with their postoperative levels being higher in the CaHA group as compared to the PCL group (P<0.01; **Figure 2**).

Safety profile analysis

Two cases of bruising, seven of swelling, and three of subcutaneous nodules were identified in the PCL group, compared to the corresponding cases of 6, 5, and 0 in the CaHA group. The data indicated a comparable total incidence of adverse reactions across the groups (P>0.05; **Table 6**).

Patient satisfaction

The number of cases who were highly satisfied, moderately satisfied, and dissatisfied was 42, 16, and 14 in the PCL group and 53, 17, and 5 in the CaHA group, respectively. A higher total satisfaction rate was determined in the CaHA group as compared to the PCL group (P=0.021; **Table 7**).

Discussion

The main characteristics of skin aging are color change (uneven pigmentation), decreased elasticity, uniform skin atrophy, loss of underlying

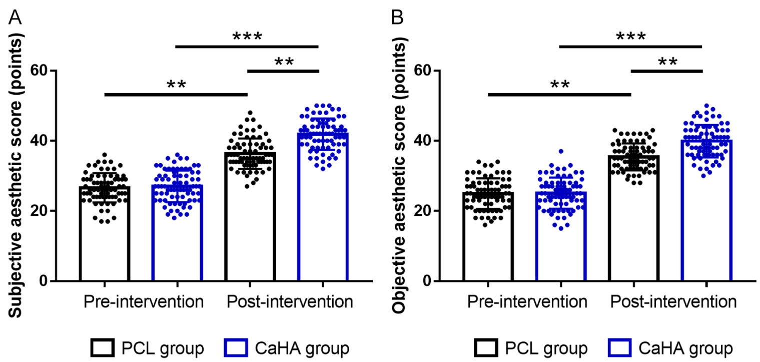

Figure 1. Facial aesthetic scores. A. Pre- and post-operative subjective aesthetic scores across groups. B. Comparative (pre- vs. post-operation) objective aesthetic scores. Note: PCL, polycaprolactone; CaHA, calcium hydroxylapatite; **P<0.01, ***P<0.001.

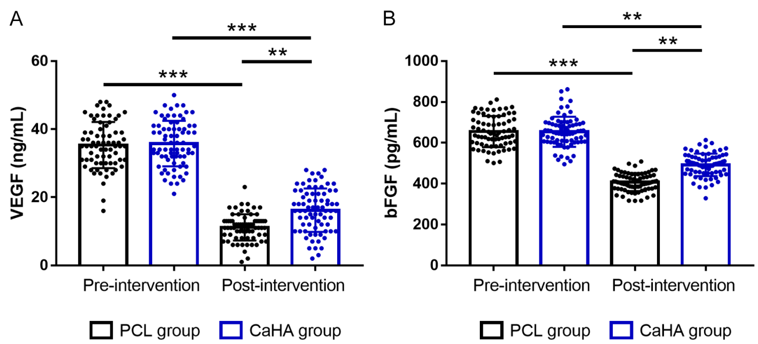

Figure 2. Serum growth factor levels. A. Pre- and post-operative VEGF across groups. B. Comparative (pre- vs. post-operation) bFGF assessment. Note: VEGF, vascular endothelial growth factor; bFGF, basic fibroblast growth factor; PCL, polycaprolactone; CaHA, calcium hydroxylapatite. **P<0.01, ***P<0.001.

tissue, and impaired barrier function [16]. Facial rejuvenation can help reverse facial aging, making patients look younger and thus be more confident and happier [17]. Firstly, this study found that facial T-zone rejuvenation with CaHA contributed to better overall curative efficacy than with PCL. This may be due to the fact that CaHA can rejuvenate the face by stimulating collagen and elastin production, facilitating angiogenesis, and promoting dermal cell proliferation [18]. In the report of Wu et al. [19], CaHA injectable fillers (eyebrow arch, lateral eyebrow, lateral cheekbone, pyriform fossa, lateral chin, and anterior medial cheek) effectively reshape the mandibular line and lift the eyebrow tail after one single treatment, which complements our study results. Meçani et al. [20] suggested that the combination of CaHA and hyaluronic acid (HA) could stimulate the synthesis of collagen through different molecular pathways, which helped further enhance aesthetic effects while boasting high safety; however, the aesthetic improvement and treatment satisfaction decreased slightly after 6 months, suggesting limited long-term effects of this therapy.

Additionally, CaHA exhibited stronger dynamic supportive strength, providing structural support akin to bones, more accurate moldability, and better maintenance effects. This may be related to the high elastic modulus (G' value: ~1,407 Pa) of CaHA, along with its superior hardness to PCL (G' value: ~983 Pa), enabling it to better simulate the skeletal support and exhibit stronger stability when resisting the traction of facial muscles such as corrugator supercilii and depressor labii inferioris [21, 22]. In clinical practice, CaHA should be preferred in injectable treatment for facial T-zone rejuvenation for those who pursue bone contour remodeling, especially in areas that need strong support, such as the nasal root and chin, given its ability to promote the overall lifting effect though precise local shaping to realize overall rejuvenation.

According to the maintenance duration evaluation, CaHA was significantly advantageous over PCL in terms of long-term effects. This could be justified by the fact that PCL mainly plays a role by stimulating collagen regeneration; its CMC carriers, however, rely on new collagen to maintain the morphology after absorption, resulting in a certain degree of resorption [23]. In contrast, the high G' value of CaHA provides it with a more durable structural support framework; moreover, the osteoconductive property of microspheres enables them to maintain their morphology for a longer time [24]. Thus, for patients with good compliance, who are seeking a reduction in treatment frequency and maintenance of long-term bene-

Table 6. Safety analysis

Items	PCL group (n=72)	CaHA group (n=75)	X^2	P
Bruising	2 (2.78)	6 (8.00)		
Swelling	7 (9.72)	5 (6.67)		
Subcutaneous nodule	3 (4.17)	0 (0.00)		
Total	12 (16.67)	11 (14.67)	0.111	0.739

Note: PCL, polycaprolactone; CaHA, calcium hydroxylapatite.

Table 7. Patient satisfaction

Items	PCL group (n=72)	CaHA group (n=75)	X^2	P
Very satisfied	42 (58.33)	53 (70.67)		
Generally satisfied	16 (22.22)	17 (22.67)		
Dissatisfied	14 (19.44)	5 (6.67)		
Satisfaction	58 (80.56)	70 (93.33)	5.329	0.021

Note: PCL, polycaprolactone; CaHA, calcium hydroxylapatite.

fits, CaHA offers clear advantages. Patients who may wish to adjust their appearance in the short term, or those with extremely high requirements for the naturalness of the touch sensation, may find the progressive collagen regeneration feature of PCL more in line with their needs.

When assessing facial skin laxity status, CaHA was confirmed to be more effective in midface lifting and lower facial contour tightening. This can be explained by the high support of CaHA, which can indirectly pull the surrounding loose soft tissues back to their original position by restoring the bony support of the nasal root and chin [25]. For patients with obvious midfacial droop and blurred mandibular contour, injecting CaHA into the T-zone can achieve both local contouring and regional lifting. Subsequently, higher subjective and objective aesthetic scores, as well as better aesthetic effects, were identified after facial T-zone rejuvenation with CaHA than with PCL.

In this study, VEGF and bFGF in CaHA-treated patients, though notably down-regulated, remained higher compared to those under PCL intervention. VEGF and bFGF, as key signaling molecules during tissue repair, can coordinate angiogenesis, cell proliferation, and tissue remodeling, and their down-regulation indicates gradual resolution of the acute inflammatory reaction mediated by NLRP3 inflammasome [26]. This helps to explain the significant VEGF and bFGF decreases following CaHA/PCL intervention. During tissue remodeling and repair processes, however, maintaining adequate VEGF and bFGF levels exerts a positive impact by enhancing vascular stability and facilitating wound healing [27]. Hence, rather than extending acute inflammation duration, CaHA maintains a microenvironment conducive to growth factor regeneration after inflammation subsides, probably by promoting angiogenesis as well as stimulating collagen-producing cell proliferation and elastin production [28]. The above information provides an explanation for the markedly higher VEGF and bFGF in patients treated with CaHA than those on PCL. A possible explanation is that CaHA may maintain a microenvironment conducive to tissue regeneration through more lasting microvascular network remodeling and fibroblast activation [29, 30]. Finally, it was found that patient satisfaction was significantly higher under the intervention of CaHA, with a favorable safety profile comparable to PCL in facial T-zone rejuvenation. This may be related to CaHA's long-lasting bony support and ideal bony hardness in areas (e.g., nasal root, chin) that need strong support, and to its longer maintenance effects and higher aesthetic effects [31]. Relevant guidelines have pointed out that strict aseptic practice, small volume injection of CaHA, precise injection location, and injection site massage can minimize the risk of complications, supporting our findings [32]. As reported by de Sanctis Pecora C et al. [33], CaHA, botulinum toxin, and HA diluted in the same syringe and injected in the same session aid in further improving the neck rejuvenation effect and patient satisfaction, echoing our results.

Clinically, individualized material selection should be made according to patients' specific demands (pursuing bony contour vs. natural transition), anatomical basis (soft tissue thickness and laxity degree), and expectations of treatment frequency. For those who prioritize bony contour and reduced treatment sessions, CaHA should be preferred. For patients who want to keep more soft tissue elasticity in areas like the nasal tip and the forehead, or prefer gradual changes, PCL may be more advantageous given its elastic properties and progressive collagen regeneration characteristics.

The following are limitations of this study: First, although the total injection volume range of all the T-zone areas is defined, there is no analysis to correlate different injection doses (e.g., stratification of low vs. high dose based on the facial volume defect degree) with efficacy and maintenance time, nor is there established individualized quantitative standards of dose selection (e.g., a dose adjustment algorithm based on skin thickness, bone foundation, or soft tissue defect volume). In the future, correlation analysis and individualized quantitative standards should be prospectively supplemented. Second, this study only compared the efficacy of the two materials, without a non-injection control or placebo injection group. As a result, it is impossible to rule out the influence of natural recovery and placebo effect on efficacy-associated indices, nor to clarify the net efficacy of the two materials. A randomized, blinded, and placebo-controlled design should be adopted in the future to verify the real therapeutic effect of the two materials.

To sum up, CaHA is clinically advantageous over PCL in injectable treatment for facial T-zone rejuvenation. It demonstrates higher efficacy, more potent supportive strength and moldability, longer maintenance time and effects, better ameliorative effects of facial skin laxity, and superior aesthetic performance. Also, it more actively adjusts serum VEGF and bFGF levels and enhances patient satisfaction while not significantly increasing overall adverse reactions.

Disclosure of conflict of interest

None.

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