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Original Article

Negative pressure sealing drainage technology combined with adequate irrigation for oral and maxillofacial space infection can improve serum inflammatory factor levels

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Abstract: Objective: This study aimed to assess the clinical efficacy of combining vacuum sealing drainage with full irrigation in managing oral and maxillofacial space infections and its impact on serum inflammatory factor levels in patients. Methods: We retrospectively analyzed data from 110 patients with oral and maxillofacial space infections treated at our hospital between February 2018 and March 2022. Among them, 50 patients underwent simple negative pressure closed drainage (control group), while 60 patients received combined full irrigation using 0.9% sodium chloride solution (observation group). We compared clinical treatment outcomes, treatment duration, antibiotic usage duration, quality of life scores, Visual Analogue Scale (VAS) scores, changes in serum IL-6 and TNF-α levels before and after treatment, and the incidence of complications between the two groups. Additionally, we conducted an analysis of risk factors influencing patient prognosis. Results: The observation group exhibited significantly superior treatment efficacy compared to the control group ($P < 0.05$). Treatment and antibiotic usage durations were shorter in the observation group ($P < 0.05$). VAS scores after treatment were significantly lower in the observation group ($P < 0.05$). Serum inflammatory factors improved significantly in both groups after treatment, with a more substantial improvement observed in the observation group ($P < 0.05$). Post-treatment quality of life was significantly higher, and the incidence of complications was lower in the observation group ($P < 0.05$). The choice of treatment method independently influenced patient prognosis ($P < 0.05$). Conclusion: Combining vacuum sealing drainage with full irrigation is an effective approach for managing oral and maxillofacial space infections. This treatment leads to improved clinical symptoms, reduced inflammatory responses, decreased pain intensity, and enhanced quality of life while maintaining safety.

Keywords: Vacuum sealing drainage, full irrigation treatment, oral and maxillofacial space infection, clinical efficacy, inflammatory factors

Introduction

Oral and maxillofacial space infections frequently occur in clinical practice, primarily due to factors like dental caries, periodontitis, and trauma, with dental issues being the main contributor. Patients often overlook these infections in the early stages [1, 2]. The complex network of interconnected spaces in the oral and maxillofacial region creates a conducive anatomical environment with optimal temperature and humidity for bacterial and microorganism growth. Infections involving multiple spaces can become severe, especially when infections originate from dental or salivary glands [3]. Besides systemic support and antimicrobial drug therapy, surgical incision and drainage are crucial interventions for managing severe space infections in the oral and maxillofacial region [4]. However, these procedures can lead to various issues, including local pain, significant scar formation, and potential secondary osteomyeli-

tis [5]. Hence, identifying appropriate treatment strategies for oral and maxillofacial space infections holds significant clinical importance.

In recent years, a novel vacuum sealing drainage (VSD) technique, incorporating a smaller wound opening and an active irrigation function, has gained traction in the medical field. This innovative approach has seen widespread adoption across departments including general surgery, orthopedics, burn surgery, and trauma surgery. It has been proven to be highly effective in managing challenging wounds, yielding favorable clinical results [5, 6]. As research progresses, scholars have applied it to treat oral and maxillofacial space infections [7, 8]. However, treating infections in this region differs from other areas due to their unique nature. This application raises numerous issues and lacks consistency in operational guidelines and usage specifics [9]. Furthermore, in clinical practice, we have observed that using the VSD technique alone can lead to biomaterial foam and catheter blockage due to the specific challenges posed by oral and maxillofacial infections.

To tackle these challenges in utilizing VSD for draining severe maxillofacial infections, we incorporated a comprehensive irrigation method. The objective was to dilute pus through continuous irrigation, mitigating the risk of dressing and catheter obstructions, thus improving drainage efficiency. We conducted a comparative analysis of efficacy between this integrated approach and exclusive VSD utilization.

Materials and methods

Clinical data

A retrospective analysis was conducted on the medical records of 110 patients diagnosed with oral and maxillofacial space infections who sought treatment at Hebei Eye Hospital between February 2018 and March 2022. Among them, 50 patients treated with isolated negative pressure sealed drainage were assigned to a control group, while the other 60 patients, who received combined treatment involving full irrigation using a 0.9% sodium chloride solution, constituted an observation group.

Inclusion criteria: ① Severe maxillofacial infections [10] caused by various factors, including infection affecting two or more spaces within the maxillofacial region; floor elevation of the mouth leading to respiratory distress or airway compression; systemic toxic symptoms such as sepsis, septicemia, or toxic shock. The presence of any of these three manifestations would classify a case as severe infection; ② Local ultrasonography or computed tomography (CT) revealing the formation of an abscess; ③ Aspiration yielding purulent fluid and meeting the indications for incision and drainage, applicable to surgical patients with extraoral incisions.

Exclusion criteria: ① Patients with incomplete clinical data; ② Patients with specific infections caused by pathogens like mycobacteria; ③ Patients with secondary infections in the context of malignant tumors. This study was approved by the ethics committee of Hebei Eye Hospital and adhered to the principles of the Helsinki Declaration.

Treatment methods

All patients underwent routine antimicrobial and symptomatic treatment while receiving VSD therapy. To begin the VSD procedure, the cutaneous tissue over the abscess site was incised. The pus cavity was thoroughly irrigated with a 3% hydrogen peroxide solution, followed by extensive irrigation using physiological saline. After irrigation, we disinfected the incision area with iodophor solution and rinsed the wound again with physiological saline. We then customized a VSD dressing to match the wound's dimensions and shape, ensuring a snug fit without dead spaces. The dressing was secured to the wound edges intermittently with sutures, and a semipermeable biologic membrane was placed on top to create a sealed closure. The drainage tube was directed out of the wound and connected directly to the negative pressure source. Upon connection, liquid and gas were rapidly extracted until no air leakage sound was detected beneath the membrane, indicating the completion of the procedure.

For patients in the observation group, a VSD dual-lumen drainage tube was employed. Continuous irrigation involved the uninterrupted use of a 0.9% sodium chloride solution for 24 hours during the entire VSD drainage process. Postoperatively, the selection of antibiotics was based on bacterial culture and susceptibility test results (Penicillins, macrolides, cephalosporins and quinolones). The efficacy was evaluated 2 weeks after treatment.

Table 1. Comparison of general data

Variable	Observation Group n=60	Control Group n=50	X^2	P
Gender			0.064	0.801
Male	37 (61.67)	32 (64.00)		
Female	23 (38.33)	18 (36.00)		
Age (years)			0.001	0.972
≥ 56	31 (51.67)	26 (52.00)		
< 56	29 (48.33)	24 (48.00)		
BMI (kg/m^2)			0.099	0.753
≥ 23	33 (55.00)	26 (52.00)		
< 23	27 (45.00)	24 (48.00)		
Smoking history			0.364	0.546
Yes	41 (68.33)	35 (62.50)		
No	19 (31.67)	15 (37.50)		
Alcohol history			0.074	0.784
Yes	43 (71.67)	37 (74.00)		
No	17 (28.33)	13 (26.00)		
Hypertension			0.121	0.723
Yes	32 (53.33)	25 (50.00)		
No	28 (46.67)	25 (50.00)		
Diabetes			0.032	0.858
Yes	23 (38.33)	20 (40.00)		
No	37 (61.67)	30 (60.00)		

BMI: body mass index.

Outcome measures

(1) Clinical treatment efficacy assessment: Excellent response was indicated by drainage output less than 10 mL/day, no pain upon tube removal, granulation tissue growth covering the wound, and complete disappearance of the abscess cavity. Effective response criteria included drainage output exceeding 20 mL/day, partial granulation tissue coverage, and incomplete resolution of the abscess cavity. Ineffective response was suggested by the absence of regression in the local abscess, persistence of the abscess cavity, and lack of granulation tissue coverage. Overall clinical response rate = Excellent response rate + Effective response rate. (2) The treatment duration (from incision and drainage of the abscess and placement of the VSD device to the day when healing criteria were met) and antibiotic usage duration were recorded and compared between the two groups. (3) ELISA was employed to measure the serum levels of IL-6 (Abacam, ab233706) and TNF-α (Abcam, ab183218) before and after treatment in both groups. (4) Visual Analog Scale (VAS) pain assessment [11] was conducted at one week postoperatively to evaluate pain levels in both groups. Higher scores indicate more intense pain. (5) The SF-36 scale [12] was applied to assess the quality of life of both groups two months after treatment. Higher scores indicate better quality of life. (6) The incidence of postoperative complications was compared between the two groups, including swelling, mandibular osteomyelitis, and hypoproteinemia.

Statistical methods

The collected data were processed and visualized using SPSS 20.0 software and GraphPad Prism 8 software, respectively. For measurement data, Student t-test and paired t-test was used for inter-group comparison and intra-group comparison, respectively, expressed as t. Chi-square test was used for comparison of enumeration data. Statistical differences were indicated when $P < 0.05$.

Results

General data comparison

The two groups were comparable because there were no evident differences identified in gender, age, and BMI between them ($P > 0.05$, **Table 1**).

Table 2. Comparison of curative effect between the two groups of patients [n (%)]

Curative effect	Observation Group n=60	Control Group n=50	X^2	P
Excellent	42 (70.00)	25 (50.00)	-	-
Effective	16 (26.67)	12 (24.00)	-	-
Ineffective	2 (3.33)	13 (26.00)	-	-
Overall response rate	58 (96.67)	37 (74.00)	11.90	0.001

Table 3. Comparison of treatment duration and antibiotic usage time between the two groups

Variable	Observation Group n=60	Control Group n=50	t/X^2	P
Treatment duration (d)	9.86±1.1	12.75±1.09	13.78	< 0.001
Antibiotic usage time (d)	6.7±0.8	8.56±1.25	9.41	< 0.001

Comparison of total response rate between the two groups

The total response rate of treatment in the observation group was 96.67%, significantly higher than 74.00% in the control group. This suggests that closed negative pressure drainage technology combined with full irrigation has good efficacy in treating oral and maxillofacial space infections. See **Table 2**.

Comparison of treatment duration and antibiotic usage time between the two groups

The treatment duration and antibiotic usage time for patients in the observation group were significantly shorter than those in the control group ($P < 0.05$), which suggests that closed negative pressure drainage technology combined with full irrigation treatment can effectively reduce the use of antibiotics. See **Table 3**.

Comparison of serum inflammatory factors between the two groups

Compared to pre-treatment levels, the serum IL-6 and TNF-α levels of patients were significantly reduced in both groups 1 week after surgery ($P < 0.05$). Notably, the serum levels of IL-6 and TNF-α in the observation group were significantly lower than those in the control group ($P < 0.05$), which suggests that closed negative pressure drainage technology combined with full irrigation treatment can effectively relieve inflammation in the body. See **Figure 1**.

Comparison of VAS scores between the two groups before and after operation

The VAS scores of the two groups of patients showed no significant difference preoperatively ($P > 0.05$). However, postoperatively, both groups exhibited a significant decrease in VAS scores compared to the pre-treatment scores ($P < 0.05$). Furthermore, the postoperative VAS scores in the observation group were consistently lower than those in the control group ($P < 0.05$). See **Figure 2**.

Comparison of SF-36 scores between the two groups after treatment

After treatment, the quality of life scores in the observation group were significantly lower than those in the control group ($P < 0.05$), indicating a superior quality of life in the observation group. See **Table 4**.

Comparison of the incidence of postoperative complications between the two groups

The incidence of adverse reactions in the observation group patients was 3.33%, significantly lower than 18.00% in the control group ($P < 0.05$). See **Table 5**.

Analysis of prognostic factors affecting patient outcomes

Based on whether patients experienced adverse outcomes, they were categorized into a favorable prognosis group of 76 cases and an unfavorable prognosis group of 34 cases. Univariate analysis revealed that age, comorbid diabetes, and whether full irrigation treatment was performed were factors influencing the prognosis (**Table 6**). Subsequently, logistic regression analysis was conducted to analyze the significant factors, and it was found that inadequate irrigation is an independent risk factor for poor patient prognosis (**Table 7**, $P < 0.05$).

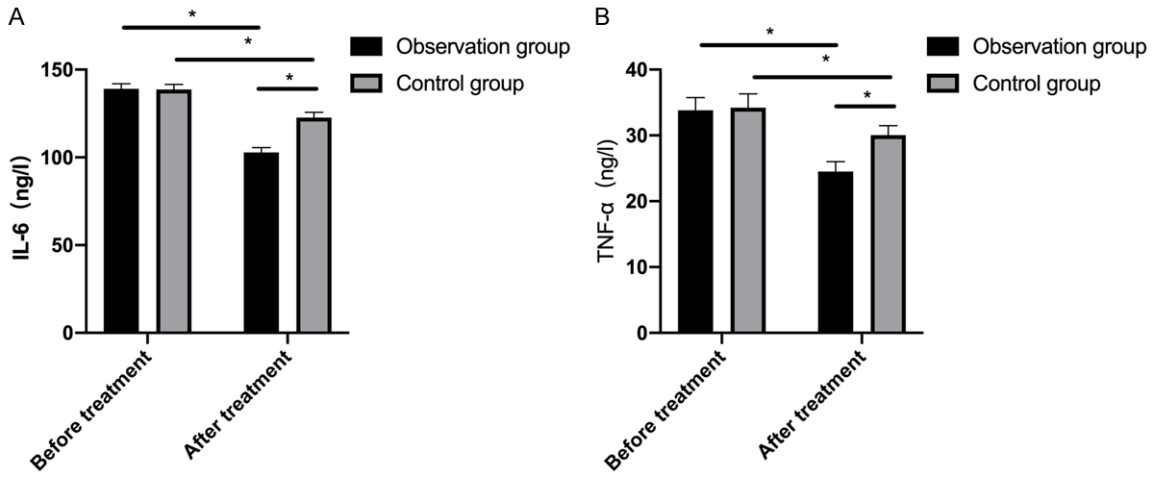

Figure 1. Comparison of serum inflammatory factors between the two groups. A: Comparison of serum IL-6. B: Comparison of serum TNF-α. * Indicates P < 0.05.

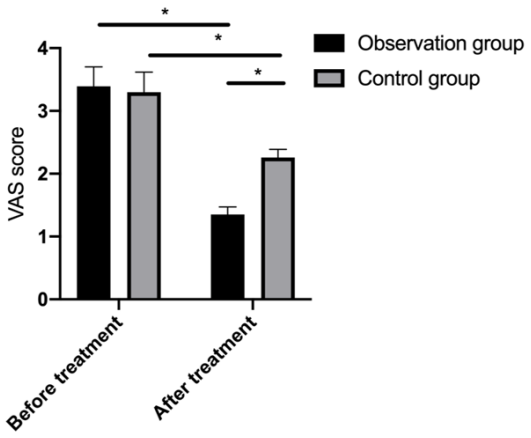

Figure 2. Comparison of VAS scores between the two groups before and after treatment. * Indicates P < 0.05. VAS: Visual Analogue Scale.

Discussion

Oral and maxillofacial space infections include dental-origin infections, salivary gland infections, traumatic infections, and hematogenous infections, with dental-origin infections being the most common. These infections, primarily caused by bacteria, greatly disrupt patients' daily lives [13]. Although incision and drainage surgeries are traditional and clinically effective treatment, it can lead to substantial patient trauma and an increased risk of postoperative complications, ultimately affecting the prognosis and recovery process negatively [14].

VSD is widely applicable in diverse wound management scenarios, including burns, pressure ulcers, infections, and wound healing, consistently delivering favorable results. The technique entails the utilization of micro-porous materials to cover or fill the wound, facilitating wound healing through negative pressure drainage. Continuous negative pressure drainage serves to eliminate necrotic tissues, enhance microcirculation, and reduce local edema [15, 16]. While employing VSD for the management of severe oral and maxillofacial space infections, we have encountered several limitations. ① Infections in the oral and maxillofacial region frequently involve Staphylococcus aureus or mixed infections, resulting in exudate containing high-viscosity proteins or colloids. This can lead to dressing and catheter blockage, diminishing drainage efficiency [17]. Catheter occlusion necessitates VSD device replacement, incurring additional costs for patients. ② The closed nature of VSD wounds presents challenges for internal examination of the drainage area. Detection of catheter blockage relies solely on monitoring changes in drainage volume and characteristics, potentially leading to misjudgments. ③ Severe oral and maxillofacial space infections often encompass multiple spaces, some of which are deep and narrow, making it challenging to achieve close contact with foam dressings. This results in reduced drainage effectiveness [18]. To tackle these challenges, we developed and applied a combination of VSD and full irrigation techniques for managing severe oral and maxillofacial space infections. The goal was to achieve pus dilution through continuous irrigation, prevent dressing and catheter blockages, and improve drainage efficiency.

Table 4. Comparison of SF-36 scores between the two groups after treatment

Item	Observation Group n=60	Control Group n=50	t	P
Social functioning	77.25±1.99	68.29±2.09	22.98	< 0.001
Mental status	74.74±2.1	68.39±1.92	16.41	< 0.001
Health Status	88.95±1.96	81.42±2.24	18.80	< 0.001
Emotional function	85.35±2.25	70.28±2.09	36.12	< 0.001

Table 5. Comparison of the incidence of postoperative complications between the two groups

Complication	Observation Group n=60	Control Group n=50	X^2	P
Swelling	1 (1.67)	3 (6.00)	-	-
Jaw Osteomyelitis	1 (1.67)	3 (6.00)	-	-
Hypoalbuminemia	0	3 (6.00)	-	-
Total incidence	2 (3.33)	9 (18.00)	6.519	0.011

Table 6. Univariate analysis

Variable	Good prognosis group (n=76)	Poor prognosis group (n=34)	X^2	P
Gender				
Male (n=69)	49 (64.47)	20 (58.82)	0.321	0.571
Female (n=41)	27 (35.53)	14 (41.18)		
Age				
≥ 56 years (n=57)	30 (39.47)	27 (79.41)	15.01	0.001
< 56 years (n=53)	46 (60.53)	7 (20.59)		
BMI				
≥ 23 kg/m^2 (n=59)	41 (53.95)	18 (52.94)	0.010	0.922
< 23 kg/m^2 (n=51)	35 (46.63)	16 (47.06)		
Smoking history				
Yes (n=76)	53 (69.74)	23 (67.65)	0.048	0.827
No (n=34)	23 (30.26)	11 (32.35)		
Diabetes				
Yes (n=43)	18 (23.68)	25 (73.53)	24.51	< 0.001
No (n=67)	58 (76.32)	9 (26.47)		
Treatment programs				
VSD (n=50)	20 (26.32)	30 (88.24)	36.33	< 0.001
VSD combined with full irrigation (n=60)	56 (73.68)	4 (11.76)		

BMI: body mass index; VSD: Vacuum sealing drainage.

Table 7. Multivariate analysis

Variable	B	S.E.	Wald	P	RR	95% C.I.	
						Lower limit	Upper limit
Treatment programs	2.743	0.732	11.792	0.002	12.3336	3.152	51.277

In comparison to patients solely undergoing VSD, we found that those receiving combined full irrigation had shorter treatment durations and antibiotic usage. It is suggested that the combination of VSD and full irrigation expedites infection healing and reduces treatment duration. Granulation tissue comprises fibroblasts, capillaries, and various inflammatory cells. As infections progress, inflammation can escalate and spread systemically. IL-6 and TNF-α are

inflammatory mediators that elevate during severe infections [19, 20]. Therefore, we analyzed serum inflammatory factors before and after treatment. Both groups showed a significant decrease in serum inflammatory factors after treatment. However, the observation group displayed a more pronounced reduction in serum IL-6 and TNF-α compared to the control group. This indicates that the combination of VSD and full irrigation contributes to a more substantial reduction in the body's inflammatory response, thereby enhancing infection management.

Prior research [21] has highlighted that elevated negative pressure can reduce interstitial pressure, facilitating autolytic debridement. VSD materials also inhibit protein phosphorylation, leading to decreased expression of associated adhesion molecules and dampening the body's inflammatory response, which corroborates our findings. Additionally, we conducted a comparative analysis of post-treatment VAS scores, complication rates, and quality of life between the two groups. The results revealed that the observation group had significantly lower VAS scores and complication rates, along with a markedly higher quality of life compared to the control group. Previous research [22] reported that VSD was the most effective method for treating oral and maxillofacial space infections. It significantly improves patients' pain status and reduces the incidence of complications, which is consistent with our observations. In this study, we employed alternating irrigation with 0.9% sodium chloride solution and hydrogen peroxide to effectively remove pus and necrotic tissue. This inert separation technique promoted connectivity between adjacent spaces, creating ideal conditions for comprehensive irrigation and drainage. This underlying mechanism elucidates the positive results obtained with the combination of VSD and full irrigation in our study.

In conclusion, VSD combined with full irrigation can effectively dilute pus, alleviate inflammatory and adverse reactions, and facilitate infection healing. As a result, it can reduce treatment duration, lower patient treatment costs, and is worthy of clinical recommendation. However, this study still has certain limitations. Firstly, the relatively small sample size necessitates further validation of our conclusions through larger-scale studies in the future. Secondly, we exclusively investigated the effects of negative pressure wound therapy combined with continuous irrigation. For patients with oral and maxillofacial space infections, whether there are other more suitable treatment approaches remains to be systematically studied.

Disclosure of conflict of interest

None.

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