Should Preoperative Computed Tomography Be Routine Examination For Cervicofacial Space Infections?

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Abstract

Background: Cervicofacial space infections are potentially life-threatening, which require accurate diagnosis, early incision, and adequate drainage. The utilization of computed tomography (CT) in cervicofacial space infections has significantly increased. However, the clinical value of preoperative CT imaging in cervicofacial space infections remains controversial. We, therefore, investigated whether CT examination should be used as a routine examination in the treatment of patients with cervicofacial space infections.

Methods: A retrospective study of all patients affected by cervicofacial space infections that received incision and drainage surgery from Jan 2016 to Dec 2020 was performed. Patients were divided into 2 groups: the group with preoperative CT and the group without preoperative CT. Outcomes, including re-operation rate, missed diagnosis rate, days of symptom relief, length of stay, duration of surgery, and total cost of hospitalization, were analyzed.

Results: Of 153 patients, 108 patients underwent surgery with preoperative CT and 45 patients without preoperative CT. The re-operation rate in the preoperative CT group (6/108, 5.6%) was significantly lower ($P < 0.05$) than that in the group without preoperative CT (10/45, 22.2%). Significant reduction of missed diagnosis rate, days of symptom relief, length of stay, and duration of surgery ($P < 0.05$) were detected in the preoperative CT group.

Conclusions: Preoperative CT examination should be recommended as a routine examination in the treatment of cervicofacial space infections for its usefulness in reducing the missed diagnosis rate and repeated surgery complication.

Introduction

Cervicofacial space infections refer to infections in potential spaces and fascial planes of the head and neck. Dental infections are common factors in the development of this severe disease [1, 2]. However, infections of deep fascial spaces of the head and neck are often underestimated and miss-diagnosed. If not treated properly, the infections will further spread within a short period time, leading to life-threatening complications, such as airway obstruction, mediastinitis, septic embolism, and dural sinus thrombosis [3, 4]. The mortality rates can be up to 38% when complications occur [5, 6].

Cervicofacial space infections require prompt and accurate management [7–9]. Accurate diagnosis, early incision, and adequate drainage are the main treatment modalities once the abscess has formed. Accurate diagnosis is a prerequisite for effective treatment without complications. However, accurate diagnosis of the cervicofacial space infections is challenging based only on history and clinical examination findings, mainly due to diffuse, ill-defined facial swelling without characteristic clinical manifestations. Previous studies have found that clinical examination alone can only accurately identify abscesses in 33–76% of cases [10, 11]. Under-diagnosis can cause the infections spread, repeated surgery, prolonged hospitalization, and increased total cost. Some surgeons, therefore, resort to the

following adjunctive techniques: 1) puncture, which can only be used as a confirmatory diagnosis of cervicofacial infections for its operational blindness, presenting a risk of under-diagnosis; 2) ultrasound imaging, which is an option for diagnosis of superficial soft tissue infections of the head and neck, however, inapplicable for deep cervicofacial spaces infections due to the interference of maxillofacial bones; 3) magnetic resonance imaging (MRI), which can offer excellent soft tissue contrast resolution, but is less accessible and requires longer acquisition time and greater patient cooperation[12, 13].

In recent years, the utilization of computed tomography (CT) for diagnosis of cervicofacial space infections has significantly increased for its advantages in aiding in identifying the location and extent of the abscess involved within a short acquisition time[13, 14]. However, some surgeons still question the clinical significance of CT for the treatment of cervicofacial space infections. A study by Rosenthal et al. [15] identified that CT yielded a poor specificity (40%) for the detection of a deep maxillofacial abscess. Vural et al.[16] also reported the accuracy of CT is 63% in identifying abscesses of cases. Furthermore, patients' concerns regarding radiation exposure, potential complications, and extra cost have also increased. Currently, there exists a wide variation in the utilization rate of preoperative CT (7.6%–93%) in the treatment of cervicofacial space infections[17–19]. Whether preoperative CT should be taken as a routine examination for cervicofacial space infections remains in debate. Until now, there are no large sample cohort clinical studies that have systematically investigated the clinical value of preoperative CT imaging for cervicofacial space infections.

The purpose of this study was to retrospectively investigate whether preoperative CT should be recommended as routine examination for cervicofacial space infections.

Methods

To address the research purpose, the authors designed and implemented a retrospective cohort study that was approved by the Research Ethics Board of the Ethics Committee, West China Hospital of Stomatology, Sichuan University. Patients with cervicofacial space infections, and who presented at our department from Jan 2016 to Dec 2020, were included in this retrospective study. Patients were divided into 2 groups: the group with preoperative CT and the group without preoperative CT. All CT scans were performed on a high-resolution CT scan with three-dimensional reconstructions (Philips MX16 EVO CT, Netherlands), and all scans were obtained at 120 kV, 7700mAs, scanning time of 17.5 s, sections thickness of 1.0 mm thickness.

To be included in the study, patients had to have a final diagnosis of cervicofacial space infections, defined as infections involving one or multiple spaces, including the pterygomandibular, submasseteric, submandibular, submental, sublingual, deep temporal, infratemporal, parapharyngeal, and pretracheal space and received surgical incision and drainage.

Patients with a history of head and neck trauma or malignancy near or at the site of the chief complaint or with incomplete records (data missing for five or more variables) were excluded from the study.

Data Collection

The following data were recorded: age, gender, presenting symptoms, involved space(s) in head and neck, history of diabetes mellitus, admission WBC (white blood cell count), tracheotomy received before surgery, “red flag” signs, re-operation rate, missed diagnosis rate, days of symptom relief, length of stay, duration of surgery, and total cost of hospitalization.

Study Variables

The primary predictor was preoperative CT. The primary outcome variables were re-operation rate and missed diagnosis rate. Re-operation refers to that patients underwent repeated surgery for incision and drainage. A missed diagnosis was determined when one or more spaces in preoperative diagnosis were not diagnosed compared to the final diagnosis.

The other variables related to the study were days of symptom relief, length of stay, duration of surgery, and total cost of hospitalization. The authors take it as symptom relief if there is an improvement when patients' temperature < 37.2°C or significant reduction of swelling and pain in the chief complaint area.

Statistical analysis

All statistical analysis was completed using IBM SPSS Statistics software (version 26.0; IBM; Armonk, NY). Pearson chi-Square test and continuity correction chi-square test was used to compare categorical data between the groups. The student's t-test was utilized to compare continuous variables between the groups. $P < 0.05$ was considered statistically significant.

Results

In total, 153 patients with cervicofacial space infections were included in the study: 94 (61.4%) men and 59 (38.6%) women with a mean age of 51.7 ± 17.4 years (range, 4 to 89 yr). Patients were divided into 2 groups: 108 patients underwent surgery with preoperative CT examination and 45 patients underwent surgery without preoperative CT examination.

The most common clinical symptom was swelling ($n=149$, 97.4%), followed by limited mouth opening ($n=136$, 88.9%) (Table.1).

Table 1
Presenting symptom(s)

Variables	All, n (%)	Preoperative CT, n (%)	Non-preoperative CT, n (%)
Swelling	149 (97.4)	106 (98.1)	43 (95.6)
Limited mouth opening	136 (88.9)	98 (90.7)	38 (84.4)
Pain	120 (78.4)	86 (79.6)	34 (75.6)
Dysphasia	30 (19.6)	24 (22.2)	6 (13.3)
Elevated floor of mouth	21 (13.7)	17 (15.7)	4 (8.8)
Dyspnea	14 (9.2)	8 (7.4)	6 (13.3)
Temperature $\geq$ 38.0°C	5 (3.3)	4 (3.7)	1 (2.2)

Most commonly affected space was the pterygomandibular space (n=91, 59.5%), followed by submandibular space (n=88, 59.5%). The distribution of the infected spaces is illustrated in Table.2. There are 96 patients with one single cervicofacial space involved, 45 patients with two spaces involved, and 12 patients with more than two spaces.

Table 2
Distribution of infected deep spaces of head and neck

Variables	All, n (%)	Preoperative CT, n (%)	Non-preoperative CT, n (%)
Pterygomandibular	91 (59.5)	65 (60.2)	26 (57.8)
Submandibular	85 (55.6)	63 (58.3)	25 (55.6)
Submasseteric	81 (53.0)	56 (51.9)	25 (55.6)
Parapharyngeal	65 (42.5)	50 (46.3)	15 (33.3)
Submental	32 (21.0)	21 (19.4)	11 (24.4)
Infratemporal	28 (18.3)	19 (17.6)	9 (20.0)
Sublingual	15 (9.8)	10 (9.3)	5 (11.1)
Deep temporal	11 (7.2)	5 (4.6)	6 (13.3)
Pretracheal	7 (4.5)	4 (3.7)	3 (6.7)

A comparison of demographics between the 2 groups is presented in Table.3. Differences showed no significance in terms of age and gender ($P > 0.05$). Further, there was also no statistical difference in the variables related to the condition of diabetes, admission WBC count $>10 \times 10^9/L$, tracheotomy received before surgery, and “red flag” signs (either of dyspnea, elevated floor of mouth, and dysphasia) on

admission and involved multiple-space infections. Thus, it can be regarded as comparable between these two groups.

Table 3
Comparison of subject demographics between the 2 groups

Study Variables	ALL	Preoperative CT	Non-preoperative CT	T/ χ^2	P-value
Sample size, n (%)	153 (100%)	108 (70.6)	45 (29.4)	NA	NA
Age (year), mean $\pm$ SD	51.7 $\pm$ 17.4	53.3 $\pm$ 17.2	47.9 $\pm$ 17.6	1.75	0.08
Gender, n (%)				0.02	0.9
Women	59 (38.6)	42 (38.9)	17 (37.8)		
Men	94 (41.4)	66 (61.1)	28 (62.2)		
Diabetes Mellitus, n (%)	19 (12.4)	14 (13.0)	5 (11.1)	0.1	0.75
Yes	134 (87.6)	94 (87.0)	40 (88.9)		
No					
WBC > 10.0 x 10 ⁹ /L, n (%)				0.55	0.46
Yes	131 (85.6)	91 (84.3)	40 (88.9)		
No	22 (14.4)	17 (15.7)	5 (11.1)		
Tracheotomy received before surgery, n (%)				0.26 ^b	0.61
Yes	11 (7.2)	9 (8.3)	2 (4.4)		
No	142 (92.8)	99 (91.7)	43 (95.6)		
"Red flag" signs, n (%)				1.14	0.29
Yes	61 (39.9)	46 (42.6)	15 (33.3)		
No	92 (60.1)	62 (57.4)	30 (66.7)		
Involved deep spaces $\geq$ 2, n (%)				0.08	0.78
Yes	57 (37.3)	41 (38.0)	16 (35.6)		
No	96 (62.7)	67 (62.0)	29 (64.4)		
<p><i>Note:</i> Pearson χ^2 test, continuity χ^2 test, and Student-t test were used for analysis, ^b: continuity χ^2 test</p> <p>"Red flag" signs: either dyspnea, the elevated floor of mouth, or dysphasia presented</p> <p>Abbreviations: NA, not applicable; SD, standard deviation; WBC, white blood cell count</p>					

Of the 158 patients who received surgical incision and drainage, 16 (10.5%) patients underwent secondary surgery. There was a significantly higher proportion of re-operation rate in the group without preoperative CT (10/45, 22.2% vs 6/108, 5.6%, $P<0.05$). When analyzing the missed diagnosis rate, there was a lower rate of missed diagnosis in the group with preoperative CT as compared with that in the group without preoperative CT (11/108, 10.2% vs 16/45, 35.6%, $P<0.05$).

The average days of clinical symptom relief were 2.39 ± 1.34 days in the preoperative CT group and 3.13 ± 1.69 days in non-preoperative group ($P<0.05$). The mean length of stay for these patients in the preoperative CT group was 10.76 days, whilst the mean length of stay for patients in the non-preoperative CT group was 12.76 days ($P<0.05$). Moreover, there was also a statistically significant difference between these 2 groups in terms of the duration of surgery (48.04 ± 23.53 mins vs 59.33 ± 28.46 mins, $P<0.05$). The average cost of hospitalization for patients in the preoperative CT group is lower than that of the non-preoperative CT group ($P>0.05$). A comparison of all study variables between the 2 groups is presented in Table 4.

Table 4
Comparison of treatment outcomes between the 2 groups

Study Variables	ALL	Preoperative CT	Non-preoperative CT	T/ χ^2	P value
Reoperation, n (%)				7.73 ^b	0.00*
Yes	16 (10.5)	6 (5.6)	10 (22.2)		
No	137(89.5)	102 (94.4)	35 (77.8)		
Missed diagnosis, n (%)				14.07	0.00*
Yes	27(17.6)	11 (10.2)	16 (35.6)		
No	126(82.4)	97 (89.8))	29(64.4)		
Days of symptom relief, mean $\pm$ SD	2.61 $\pm$ 1.48	2.39 $\pm$ 1.34	3.13 $\pm$ 1.69	4.92	0.01*
Length of stay(days), mean $\pm$ SD	11.35 $\pm$ 5.25	10.76 $\pm$ 4.94	12.76 $\pm$ 5.73	-2.17	0.03*
Duration of surgery(mins), mean $\pm$ SD	52.48 $\pm$ 28.86	48.04 $\pm$ 23.53	59.33 $\pm$ 28.46	-2.54	0.01*
Total cost of hospitalization (¥), mean $\pm$ SD	13147.65 $\pm$ 6829.33	12913.37 $\pm$ 6904.07	13709.91 $\pm$ 6689.21	-0.66	0.51
<p><i>Note:</i> Pearson χ^2 test, continuity χ^2 test and Student-t test were used for analysis, ^b: continuity χ^2 test</p> <p>Abbreviations: SD, standard deviation</p> <p>*statistically significant</p>					

Discussion

Cervicofacial space infections are potentially life-threatening that require accurate diagnosis and prompt management. The application of CT imagine has increased for cervicofacial space infections, due to its advantages in the identification of the location and extent of the abscess. However, there has been debate regarding whether preoperative CT should be a routine examination for cervicofacial space

infections. This study was designed to analyze the contribution of preoperative CT to the management of cervicofacial space infections and investigate the necessity of preoperative CT as a routine examination.

Due to complex anatomical location and absence of characteristic clinical manifestations, cervicofacial space infections are often under-diagnosed, which can lead to inadequate drainage and repeated surgery [18, 20]. Re-operation is the most common adverse event after treatment of deep cervicofacial space infections, greatly increasing patients' physical and mental burden. Sharma et al [19] and Christensen et al. [21] demonstrated that patients with multiple cervicofacial spaces infections are more likely to undergo re-operation. Thus, our study takes the re-operation rate as the primary variable. A total of 16 out of 153 patients underwent re-operation, making the rate of re-operation in the whole study population 10.5%. There is a significant decrease rate of repeated surgery in the preoperative CT imaged group as compared to the group without preoperative CT (10/45, 22.2% vs 6/108, 5.6%, $P < 0.01$). The result showed that preoperative CT examination provides important information in diagnosing cervicofacial space infections, which can guide the treatment course. The results demonstrated patients without preoperative CT are more likely to have repeated surgery for the cervicofacial space infections and uncontrolled inflammation spreading to other adjacent spaces. This highlights the importance of preoperative CT for the treatment of cervicofacial space infections, providing an effective guide for surgical incision and drainage of deep cervicofacial infections.

Accurate diagnosis of deep cervicofacial space infections is the key element for avoiding unnecessary repeated surgery. However, the absence of characteristic clinical presentations often leads to missed diagnosis and delayed treatment. The results showed the rate of missed diagnosis is 35.6% (16/45) in the group without preoperative CT, whereas only 10.2% (11/108) in the group with preoperative CT (shown in Table.4). It is not difficult to find a lower missed diagnosis rate and a correspondingly lower rate of repeated surgery in the preoperative CT imaged group. The results of this study demonstrated that with the aid of CT examinations, the rate of missed diagnosis and the risk of re-operation can be significantly reduced. Therefore, it can be confirmed that preoperative CT plays a crucial role in providing adequate information in managing cervicofacial space infections. Of all the missed-diagnosis cases, the most commonly neglected spaces in our study are pterygomandibular and parapharyngeal spaces.

The results also revealed that the use of preoperative CT examinations was significantly effective in improving clinical outcomes of cervicofacial space infections, including the days of symptom relief, the length of hospitalization, and the duration of surgery (shown in Table.4). This further emphasizes the significant value of preoperative CT for defining the precise location and extent of complicated infections and offering an effective medical guide for surgical procedures.

In the present study, the total cost in patients with cervicofacial space infections was also analyzed. Interestingly, the average total cost of hospitalization did not increase in the group with preoperative CT (shown in Table.4). We speculate that the most likely reason is that the application of preoperative CT shortened the length of stay and minimized the risk of repeated surgery, therefore indirectly decreasing the cost of hospitalization. Similarly, a study by Zawia et al^[7] also suggested that accurate diagnosis

and treatment of odontogenic infections in head and neck regions can lower treatment costs. Therefore, from the aspect of health economic, preoperative CT provides significant value in the treatment of cervicofacial space infections.

Vestibular space infection, palatal space infection, and simple dentoalveolar abscess were not included in this study as it was a retrospective analysis of hospitalized patients with cervicofacial space infections. The majority of these cases present with moderate or severe symptoms when admitted to the hospital. Superficial infections are usually managed in the outpatient department.

There were still several limitations in this study, such as the retrospective study design and the results obtained from a single center. Although we advocate that preoperative CT examination should be recommended as a routine examination in the treatment of cervicofacial space infections, a prospective and multiple-center clinical study should be performed.

Conclusion

In conclusion, our results revealed that the preoperative CT examination, as an adjunct examination, significantly reduces the missed diagnosis rate and minimizes the risk of repeated surgery in the treatment of cervicofacial space infections. Therefore, we recommend preoperative CT as a routine examination for cervicofacial space infections.

Abbreviations

CT: computed tomography; WBC: white blood cell count.

Declarations

Acknowledgments

None.

Author contributions

Jiayu Liang contributed to the study concept, design, data acquisition, data interpretation, data analysis, and drafting of the manuscript. Linli Jiang and Maoye Li contributed to data acquisition and data interpretation. Lei Liu contributed to data interpretation and revision of the manuscript; Hui Li contributed to the study concept, design, data interpretation, and critical revision of the manuscript. All authors gave final approval and agree to be accountable for all aspects of the work.

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Availability of data and materials

The datasets generated and/or analysed during the current study are not publicly available due to privacy or ethical restrictions but are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

This study was approved by the Research Ethics Board of the Ethics Committee, West China Hospital of Stomatology, Sichuan University with the reference number: WCHSIRB-D-2021-056. Informed consent was waived by the Research Ethics Board of the Ethics Committee, West China Hospital of Stomatology, Sichuan University due to the retrospective nature of the study. All methods were carried out in accordance with relevant guidelines and regulations.

Consent for publication

Not applicable.

Competing interests

None.

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