Necrotic Lesions Associated with Desomorphine ("Krokodil") Drug Abuse: a Systematic Review

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ABSTRACT

Objectives: This systematic review of case reports and case series aims to identify the types of necrotic alterations caused by desomorphine ("Krokodil") and the diagnostic methods used in such cases.
Material and Methods: An advanced search was conducted on 30 January 2025 in the Web of Science, Scopus, and PubMed databases using the selected keywords and MeSH terms. The research was conducted in accordance with the PRISMA guidelines. A total of 54 records were identified and screened for eligibility. After meticulous evaluation by two independent reviews, 15 articles were included in this systematic review.
Results: Of the included 251 cases, 247 discussed osteonecrosis of the facial bones. Three out of the four cases discussing limb necrosis presented a high risk of bias. The most commonly used paraclinical diagnostic methods were: radiological examination (radiographs, cone-beam computed tomography, etc.), histopathological examination, microbiological tests, and blood tests. Other less common methods included scintigraphy and C-terminal telopeptide tests. This systematic review did not identify enough cases discussing desomorphine-associated skin lesions.
Conclusions: Desomorphine ("Krokodil") is a dangerous drug that causes different local and systemic damages, including soft-tissue lesions and bone necrosis. Future studies should focus on the distribution of the necrotic lesions according to the affected tissues/organs, and the possible correlation between the drug use period and the clinical findings.

Keywords: desomorphine; krokodil; necrosis; ulcers.

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INTRODUCTION

"Krokodil" is a low-cost home-produced drug used as a heroin replacement. The records of its first use were from Russia and other Eastern European countries. The prevalence of its use was estimated to be about 100,000 people in Russia and 20,000 in Ukraine in 2011 [1]. It contains different substances with devastating local and systemic effects. The main constituent of "Krokodil" is desomorphine (dihydrodesoxymorphine-D or 4,5α-epoxy-17-methylmorphinan-3-ol), with strong opioid and psychoactive properties. It has been produced using codeine-containing medicines and additives, such as red phosphorous, iodine, etc. [2,3]. The name "Krokodil" derives from the word "crocodile", as the drug causes necrotic green or black skin lesions, resembling the skin of a crocodile [1]. Desomorphine demonstrated higher dependence potential than morphine [4]. The reported dependence effects of morphine and desomorphine, presented as reciprocals, are 1/50 and 1/10.1, accordingly [5].

"Krokodil" administration can be oral, intravenous, and subcutaneous [6]. It is most commonly administered intravenously, leading to thrombophlebitis and other mutilating complications, including soft tissue necrotic lesions of the limbs and even amputations. Osteomyelitis of the tibia and fibula has also been registered [7]. These complications have been associated with the by-products of the synthesis process [8]. Petrol and hydrochloric acid induce skin scaling and ulcerations, while iodine damages the muscular tissue and the endocrine system. Damages to the internal organs (endocarditis, myocarditis, heart failure, cardiogenic shock, acute coronary syndrome, renal and liver failure, internal abscesses, ischemic or haemorrhagic stroke, etc.) have also been reported. Another serious complication is facial bone necrosis. The most frequently reported triggering factor for jaw necrosis is tooth extraction. The onset of osteonecrosis is usually within the first 1 to 1.5 years after the extraction [8-10]. Other predisposing factors include badly fitting dentures and imprecise fixed restorations, causing trauma and plaque retention and contributing to the development of periodontal disease [11-13].

The exact pathogenesis is unclear but it has been compared to the medication-related osteonecrosis of the jaws (MRONJ), and the long-described "phossy jaw" (phosphorous osteomyelitis) among factory workers. It has been stated that similar to MRONJ "Krokodil"-associated osteonecrosis of the jaw affects more frequently the mandible than the maxilla [3,14]. The subcutaneous administration has been reported to cause skin necrotic lesions and internal organs toxicity in rats [15]. The scientific data regarding the oral route of administration of desomoprhine are scarce. There is only one case report [16] presenting the possible effects if the intraoral ingestion. The study suggests that the drug can cause abdominal pain and gastroenteritis [16].

The delayed treatment and continuous drug abuse can lead to life-threatening conditions, such as endocarditis, meningitis, pneumonia, multiple organ failure, and so on. The social aspect of this addiction should be taken into consideration. These patients usually avoid hospitalization until the symptoms become intolerable. Patients with desomorphine-associated osteonecrosis usually require multiple-stage surgery which they frequently refuse [17].

This systematic review aims to identify the types of necrotic alterations caused by desomorphine ("Krokodil") and the diagnostic methods that can be used to evaluate tissue damage and plan subsequent treatment.

MATERIAL AND METHODS

Protocol and registration

This systematic review strictly followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [18,19].

The review protocol was prospectively registered (on 19 January 2025) in the Open Science Framework (https://doi.org/10.17605/OSF.IO/DK4EQ) and can be accessed at https://osf.io/dk4eq.

Focus question

The research question was structured following the PEO framework (patients, exposure, outcomes) - a modification of the PICO framework, used for correlation between exposure and outcomes (Table 1).

Table 1. PEO Framework

Patients (P)	Patients with a history of drug abuse
Exposure (E)	Exposure to desomorphine ("Krokodil")
Outcomes (O)	Tissue/organ necrosis
Focus question	What are the tissue/organ necrotic alterations caused by desomorphine ("Krokodil") in patients with a history of their use? What diagnostic methods were used in these patients, depending on the damaged tissue/organs?

The primary objective was: "What are the tissue/organ necrotic alterations caused by desomorphine ("Krokodil") in patients with a history of their use?" Secondary objective: "What diagnostic methods were used in these patients, depending on the damaged tissue/organs?"

Types of participants/population

The review considered studies involving patients who developed necrotic lesions following administration of desomorphine ("Krokodil").

Types of studies

The present review included human studies that were published in English. The review included only clinical studies (case reports, case series, and clinical trials) without any time frame regarding their publication date.

Information sources

An advanced search was conducted on the three databases: Web of Science, Scopus, and MEDLINE (PubMed). This systematic review excluded preclinical trials, review articles, books, book chapters, abstracts, editorials, and PhD theses.

Search

The search was conducted between January 1, 2024 and January 1, 2025 in all databases. There was no time frame as a filter for the studies. The following search strategies were used in the selected databases:

1. Web of Science: (ALL=(krokodil OR desomorphine)) AND ALL=(necrosis) and Article (Document Types).
2. Scopus: (krokodil OR desomorphine) AND necrosis AND (LIMIT-TO (LANGUAGE, "English")) AND (LIMIT-TO (DOCTYPE, "ar")).
3. PubMed: Search: (krokodil OR desomorphine) AND (necrosis) Filters: Case Reports, Clinical Trial, Randomized Controlled Trial, English ((("desomorphine"[Supplementary Concept] OR "desomorphine"[All Fields] OR "krokodil"[All Fields] OR ("desomorphine"[Supplementary Concept] OR "desomorphine"[All Fields])) AND ("necrose"[All Fields] OR "necrosed"[All Fields] OR "necrosi"[All Fields] OR "necrosing"[All Fields] OR "necrosis"[MeSH Terms] OR "necrosis"[All Fields] OR "necroses"[All Fields])) AND ((casereports[Filter] OR clinicaltrial[Filter] OR randomizedcontrolledtrial[Filter]) AND (english[Filter])).

Inclusion and exclusion criteria

Inclusion criteria

The inclusion criteria were:

- Clinical studies discussing tissue/organ damages correlated with desomorphine ("Krokodil") use.
- Studies presenting the clinical symptoms in such patients.
- Studies discussing diagnostics.
- Studies written in English.

Exclusion criteria

The exclusion criteria were:

- Preclinical studies and review articles.
- Studies discussing medication-related osteonecrosis of the jaws, caused by other substances.
- Studies without open access.

Sequential search strategy

The results were exported to Microsoft Office Excel® 2016 (Microsoft Corporation; Washington, USA) file, including the study title, authors, publication year, and abstract. First, all duplicate studies were identified and removed. Then the titles and abstracts were assessed for eligibility by two reviewers (E.S. and D.D.). As a next step, the full texts of the remaining studies were evaluated. Discrepancies between the two reviewers were resolved by discussion, analysis, and consensus.

Data extraction and data items

The following information was retrieved from each study: authors, study design, affected tissues/organs, drug use duration, drug withdrawal, clinical symptoms, and diagnostic methods.

Quality assessment

The Joanna Briggs Institute (JBI) Critical Appraisal Checklist for case reports and case series (Tables 2 and 3) were used for quality assessment [20]. They consist of eight (case reports) to ten questions (case series). Each question answered with "yes" scored 1 point, while "no", "unclear", and "not applicable" scored 0. A low risk of bias was registered in studies with ≥ 7 points; a medium risk in studies with 5 to 6 points, and a high risk when the score was < 5 [21]. In cases of discrepancies between the reviewers, the decisions were taken after discussion and consensus.

Table 2. The Joanna Briggs Institute Critical Appraisal Checklist for case reports

Question number	Defined question
Q1	Were patient's demographic characteristics clearly described?
Q2	Was the patient's history clearly described and presented as a timeline?
Q3	Was the current clinical condition of the patient on presentation clearly described?
Q4	Were diagnostic tests or assessment methods and the results clearly described?
Q5	Was the intervention(s) or treatment procedure(s) clearly described?
Q6	Was the post-intervention clinical condition clearly described?
Q7	Were adverse events (harms) or unanticipated events identified and described?
Q8	Does the case report provide takeaway lessons?

Table 3. The Joanna Briggs Institute Critical Appraisal Checklist for case series

Question number	Defined question
Q1	Were there clear criteria for inclusion in the case series?
Q2	Was the condition measured in a standard, reliable way for all participants included in the case series?
Q3	Were valid methods used for identification of the condition for all participants included in the case series?
Q4	Did the case series have consecutive inclusion of participants?
Q5	Did the case series have complete inclusion of participants?
Q6	Was there clear reporting of the demographics of the participants in the study?
Q7	Was there clear reporting of clinical information of the participants?
Q8	Were the outcomes or follow up results of cases clearly reported?
Q9	Was there clear reporting of the presenting site(s)/clinic(s) demographic information?
Q10	Was statistical analysis appropriate?

Statistical analysis

Microsoft Office Excel® 2016 was used for data analysis. The quantitative measurement of the inter-rater agreement level was made by Cohen's kappa coefficient (κ).

RESULTS

Study selection

Fifty-four potentially relevant studies were found by the initial search in the three selected databases. The exclusion of 10 duplicate records led to 44 remaining studies for further evaluation. Then articles not meeting the eligibility criteria were removed and, thus, 15 studies [8,9,11,14,17,22-31] were included in the systematic review (Figure 1).

The level of agreement between two authors (E.S. and D.D.) in the selection of titles and abstracts was measured at κ = 0.9526 (almost perfect agreement).

Study exclusion

Two articles were excluded from the present systematic review following the full-text assessment: 1 review article [2] and 1 article [16] not presenting cases of "Krokodil"-induced necrosis.

Quality assessment of the included studies

According to the JBI Critical Appraisal tool for case reports: 3 cases demonstrated a high risk of bias [26-28], 4 cases - medium risk [8,9,30,31] and two cases - a low risk [17,22] (Table 4). The case series were characterized accordingly: 3 studies presented a medium risk of bias [23-25] and 3 studies a low risk of bias [11,14,29] (Table 5).

Study characteristics

Out of 15 articles included in this systematic review, 9 were case reports, and 6 case series. The earliest study was from 2014 and the latest from 2023 (Table 6). From the presented studies, 247 out of 251 cases discussed osteonecrosis (in combination with soft tissue necrotic lesion) of the facial bones. The other four cases discussed soft tissue necrosis of the limbs (Table 7). However, three out of those 4 studies presented a high risk of bias. It was evident that desomorphine-associated bone and soft tissue necrosis affected men predominantly (89% in men vs. 11% in women).

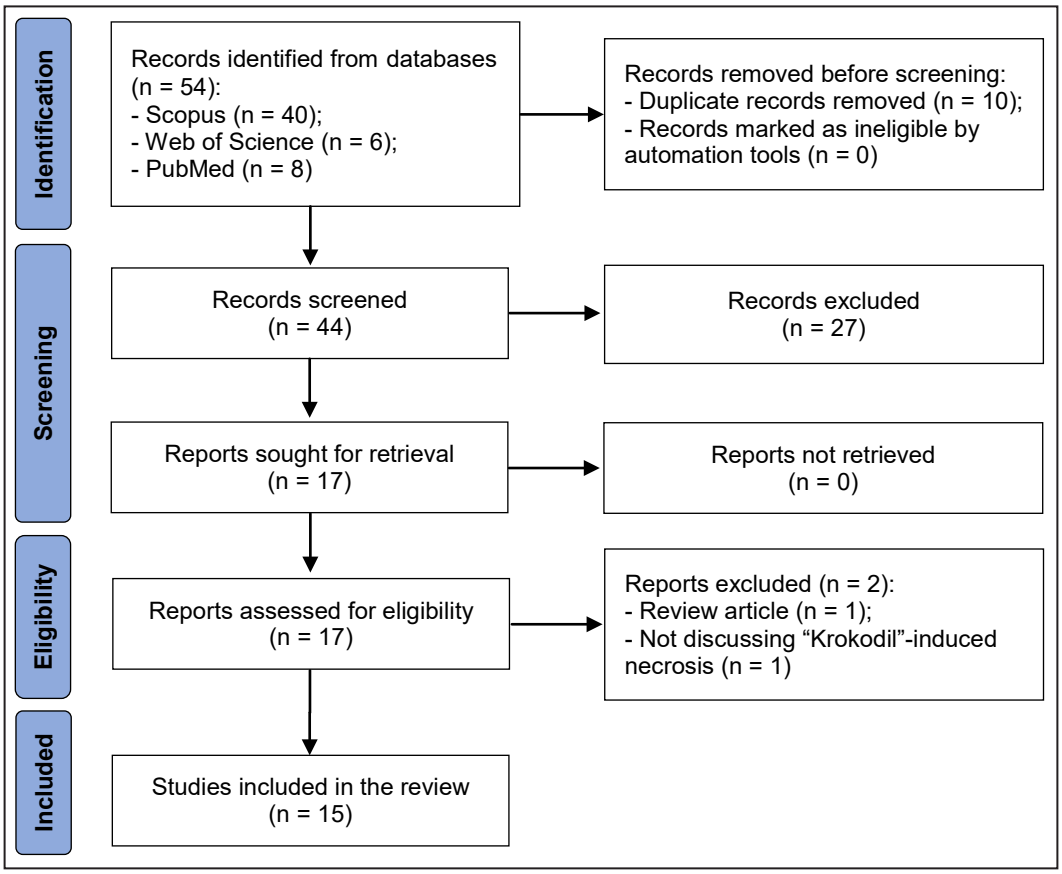

Figure 1. PRISMA flow diagram of the study.

Table 4. Results of case reports from The Joanna Briggs Institute Critical Appraisal Checklist

Study	Year of publication	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
Hussain et al. [8]	2023	+	-	+	+	-	-	-	+
Hakobayan and Poghosyan [9]	2017	+	+	+	+	+	-	-	+
Ramishvili et al. [17]	2023	+	+	+	+	+	+	-	+
Hakobyan and Poghosyan [22]	2017	+	+	+	+	+	+	-	+
Haskin et al. [26]	2016	+	-	+	+	-	-	-	?
Ghazawi and Beecker [27]	2019	+	-	+	+	-	-	-	+
Thekkemuriyi et al. [28]	2014	+	+	+	-	+	-	-	?
Poghosyan and Hakobyan [30]	2022	-	-	+	+	+	+	-	+
Sorrentino et al. [31]	2018	+	+	+	+	NA	NA	NA	+

? = unclear; + = yes; - = no; NA = not applicable.

Table 5. Results of case series from The Joanna Briggs Institute Critical Appraisal Checklist

Study	Year of publication	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Poghosyan et al. [11]	2014	+	+	+	U	+	+	+	+	+	+
Babkova et al. [14]	2019	+	+	+	-	+	+	?	-	+	+
Hakobyan and Poghosyan [23]	2019	+	+	+	?	?	?	+	+	+	?
Hakobyan et al. [24]	2017	+	+	+	?	?	+	-	-	-	+
Hakobyan and Poghosyan [25]	2022	+	?	?	?	+	-	+	+	+	+
Ispiryan et al. [29]	2023	+	+	+	+	+	+	+	+	+	+

? = unclear; + = yes; - = no; NA = not applicable.

Table 6. Characteristics of included studies

Study	Study design	Gender	Affected tissue/organ	Drug use duration	Drug withdrawal	Clinical symptoms	Diagnostics
Hussain et al. [8]	Case report	Male	Left hand and wrist	Not reported	Not reported	Skin ulcers with purulent exudation, cardiac arrhythmia, deep vein thrombosis	Clinical examination; blood tests, electrocardiography, ultrasound
Hakobayan and Poghosyan [9]	Case report	Male	Maxilla, mandible and surrounding soft tissues	1.5 years	8 months	Cutaneous fistulas with purulent exudation, opening in the submandibular areas; partially exposed left upper jaw and fully exposed lower jaw; exposed bone in yellowish grey colour and covered with grey plaques; empty socket with purulent exudation; pale oral mucosa with hyperaemic areas	Clinical and radiological examination (the latter was not presented)
Poghosyan et al. [11]	Case series: 40	Male: 39, female: 1	Maxilla: 11, mandible: 21, both: 8	Not reported	≥ 1 month	Exposed necrotic bone in yellow-grey colour with grey plaques, empty socket, purulent exudate, inflamed mucosa, fistulas	Clinical examination, tests for hepatitis B, C, and HIV, histopathological examination, radiographs
Babkova et al. [14]	Case series: 108	Male: 97, female: 11	Facial skull. Upper jaw: 34, lower jaw: 49, both: 25	2 months to 10 years	Non stated	Gingival recessions, exposed alveolar ridge, greyish or yellowish-brown bone	Clinical examination; microbiological tests; anteroposterior skull X-ray; OPG; MSCT; CBCT; radionuclide bone scintigraphy
Ramishvili, et al. [17]	Case report	Male	Right distal region of mandible	6 years	No	Unpleasant taste, spontaneous teeth loss, swelling, exposed alveolar ridge, purulent discharge, restricted jaw mobility, pain, paraesthesia, sub-febrile temperature, pathological fracture	Clinical and radiological examination, blood tests, abdominal ultrasound, electrocardiography, histopathological examination
Hakobyan and Poghosyan [22]	Case report	Male	Maxilla, surrounding oral mucosa, and maxillary sinus	1.5 years	5 months	Partially exposed right maxilla with yellowish-grey colour and grey plaques; empty sockets filled with pus; pale oral mucosa with hyperaemic areas; purulent exudation through the gingival sulci and mobile teeth	Clinical examination and CT
Hakobyan and Poghosyan [23]	Case 1	Male: 3	Right midface and maxilla	1 year	14 months	Skin fistulas; exposed alveolar ridge; mobile teeth; inflamed mucosa	Clinical examination, CBCT
	Case 2	Not reported	Left midface	2 years	1 year	Zygomatic bone exposure; soft tissue defect with a purulent exudation	Clinical examination, CBCT
	Case 3	Male	Right midface and alveolar ridge bilaterally	3 years	8 months	Extraoral edema; exposed alveolar ridge; mobile teeth; inflamed mucosa	Clinical examination, CBCT
Hakobyan et al. [24]	Case series: 17	Male	Maxilla: 1, mandible: 10, both: 6	5 to 72 months	1 to 15 months	Not reported	C-terminal telopeptide tests
Hakobyan and Poghosyan [25]	Case series: 24	Not reported	Distal mandible	6 to 36 months	10 to 48 months	Exposed bone with grey-yellow colour and inflamed soft tissues; purulent discharge; pain	Not specified
Haskin et al. [26]	Case report	Female	Both forearms and hands	Once	12 months	Non-healing ulcers, necrosis, pain, edema, purulent discharge, unpleasant smell,	Clinical examination, histopathological examination; contrast-enhanced CT
Ghazawi and Beecker [27]	Case report	Male	Legs	Not reported	Not reported	Leg necrotic ulcers with black scale, pain	Histopathological examination; microbiological test
Thekkemuriyi et al. [28]	Case report	Male	Left thigh	6 to 7 months	Not reported	Necrotic ulcers, pain, swelling, auto-amputated little finger	Not reported
Ispiryan et al. [29]	Case series: 50	Male: 41, female: 9	Maxilla ± zygomatic bone ± floor of orbit	≥ 1 year	≤ 3 months	Exposed bone for at least 2 months, extraoral and/or intraoral fistulas with purulent discharge, unpleasant smell, pain, swelling, malocclusion	Clinical examination, urinalysis, standard and biochemistry blood tests, microbiological tests, skull radiography, OPG, CT, scales for pain and edema assessments
Poghosyan and Hakobyan [30]	Case report	Not reported	Left maxilla, zygomatic bone and lateral border of the orbit, skull base	4 years	3 years	Defect of the soft tissue in the infraorbital area, exposed lateral border of the orbit, diplopia, exposed jaw bone intraorally with an OAC	Clinical examination, CT
Sorrentino et al. [31]	Case report	Male	Both forearms, heart, brain, lungs, liver, lymph nodes	Not reported	Not reported	Necrotic ulcerations on the forearms, dyspnea, sweating, tachycardia, cardiac arrest	Autopsy

OPG = orthopantomogram; CT = computer tomography; MSCT = multi-slice computer tomography; CBCT = cone beam computer tomography; OAC = oroantral communication.

Table 7. Distribution of the areas, presented with "Krokodil"-induced necrotic lesions

Study	Affected bone/tissue	Number of cases	Percentage
Hussain et al. [8]	Skin	5	2%
Poghosyan et al. [11]	Upper jaw	97	39%
Babkova et al. [14]			
Hakobyan et al. [24]			
Ispiryan et al. [29]			
Poghosyan and Hakobyan [30]			
Poghosyan et al. [11]	Lower jaw	105	42%
Babkova et al. [14]			
Ramishvili, et al. [17]			
Hakobyan et al. [24]			
Hakobyan and Poghosyan [25]			
Hakobyan and Poghosyan [9]	Both jaws	41	16%
Poghosyan et al. [11]			
Babkova et al. [14]			
Hakobyan and Poghosyan [22]			
Hakobyan et al. [24]			
Hakobyan and Poghosyan [23]	Midface	3	1%
Haskin et al. [26]			
Ghazawi et al. [27]			
Thekkemuriyi et al. [28]			
Sorrentino et al. [31]			

It must be noted, that some of the cases with osteonecrosis of the facial bones were case series by the same authors. Therefore, if some of the cases were included multiple times, the exact number of presented patients with osteonecrotic lesions would be unclear.

The longest drug use period reported was 10 years and the longest drug withdrawal period was 4 years. The shortest drug withdrawal period before surgery was 1 month. The most commonly used paraclinical diagnostic methods were: radiological examination (radiographs, CT, cone-beam computed tomography [CBCT], etc.), histopathological assessment, microbiological tests, and blood tests. Other less common methods included scintigraphy and C-terminal telopeptide tests.

DISCUSSION

Summary of evidence

The results demonstrate that men were 8 times more frequently affected than women (89% vs. 11%) which most likely represents the gender ratio of drug use. The most commonly affected facial bone was the mandible but without a significant difference compared to the maxilla (42% vs. 39%). These results correspond to the reports by van Kempen and Brand [3] and are explained by the anatomical characteristics of the lower jaw, such as high bone density, less compact bone-spongy bone ratio, and reduced vascular supply than the maxilla. These characteristics have been reported as contributing factors for the development of osteomyelitis, osteoradionecrosis, infection, inflammation, and MRONJ [32]. The main theories for its pathophysiology include inhibited bone remodeling, inhibited angiogenesis, infection, inflammation, and immune suppression. Osteonecrosis in the midface area can be primary, due to untreated necrosis of the maxilla, or due to osteonecrosis recurrence [23]

The triggering factors for the development of desomorphine-associated osteonecrosis include tooth extraction (most commonly), local trauma, poor oral hygiene, periodontitis, and lesions of endodontic origin [11]. Ill-fitting dentures or fixed prosthetic restorations traumatize the oral tissues and become plaque-retentive factors [12,13], which can further deteriorate the condition.

The clinical symptoms depend on the affected tissues. Thrombophlebitis with skin ulcers, swelling, purulent discharge, and necrotic lesions are common findings on the arms and legs. When the jaws and other facial bones are affected, the common manifestations include bone exposure, gingival recessions, suppuration, empty dental sockets, pain, swelling, foul smell, and fistula formation. It has been claimed that the pain is usually relieved by the desomorphine itself as it has up to 10 times stronger effect than morphine. This additionally postpones the patient's arrival for medical help [3,6].

A timely and correct radiological assessment, including orthopantomograms, multislice computed tomography (MSCT), CBCT, single-photon emission computed tomography (SPECT), and radionuclide diagnostic methods, is necessary to determine the extent of the necrotic lesions and the involvement of the adjacent structures. These methods provide precise identification of the pathological alterations (localization and prevalence) and allow for accurate treatment planning [14]. CBCT is the treatment of choice in most cases, providing a detailed visualization of the facial bones and alveolar crests [33,34]. However, MSCT is preferred when evaluation of the surrounding soft tissues and fistula detection is required [14]. It should be noted that despite the sensitivity of MSCT, the micro-level

spread of the damage can be greater and can be detected only during the surgery and based on clinical examination [29]. Other diagnostic methods include microbiological examination, histopathological examination, and standard and biochemistry blood tests for evaluation of the patient's general condition and immune status. The use of electrocardiography and abdominal ultrasound has also been reported to identify internal organ damage. Tests for hepatitis and HIV are also performed.

Hakobyan et al. [24] found a strong positive correlation between the C-telopeptide levels and the sequestrum and demarcation processes. Thus, C-telopeptide can be used as a predictor for the presence of demarcation [17].

The regenerative potential of the bone can be assessed with histological and histomorphometric examination [35-38] which can be necessary for the subsequent tissue regeneration.

Bone deficiency in the maxillofacial area can be due to congenital defects, trauma, infection, neoplasms and etc. [39-42]. In about 40% of the patients, segmental resections of the lower jaw were performed, resulting in bone defects of different sizes [9]. Various materials for bone regeneration with improved properties have been recently introduced and novel methods for flap reconstructions and tissue augmentation have been suggested [43-48]. They aim to preserve the existing tissues, improve bone quality and quantity, and ensure the success of implant rehabilitation [49-54]. However, osteonecrotic lesions require radical surgery to minimize the risk of recurrence. As a result, the possibilities of subsequent rehabilitation procedures are often unsatisfactory. Implant placement can be performed simultaneously or in a second-stage surgery. A reported complication of radical bone resection in the upper jaw is the development of an oroantral communication. Hakobyan and Poghosyan [22] recently reported a spontaneous closure of such a defect. In addition, some novel methods for surgical closure avoid flap replacement and additional soft-tissue loss [55,56].

Soft tissue lesions are treated with wound care procedures and appropriate antimicrobial therapy. More complicated cases may require debridement, soft-tissue grafting, and even amputation. The long-term treatment success is difficult to determine as most of the patients are lost to follow-up [26]. Some reports suggest that desomorphine-induced damages frequently lead to death [1,4].

Limitations

The results of this systematic review should be interpreted with caution since case reports and case series have low level of evidence. In addition, only open-access articles written in English were included, which reduces the review's scope, especially regarding the fact that most cases originate from Eastern Europe and studies in the native languages were not included in the selection process. Furthermore, the review did not consider the effect of possible confounding factors, such as smoking, alcohol or other recreational drug. This study did not find enough cases of skin necrosis (three out of four studies discussing limb necrosis presented a high risk of bias). Further research is necessary to identify their clinics, diagnostics, and treatment modalities. Future studies should also focus on the distribution of the necrotic lesions according to the affected tissues/organs, the role of different confounding factors, and the possible correlation between the drug use period and the clinical findings.

CONCLUSIONS

The study's results demonstrate that osteonecrosis of the facial bones is a common manifestation of desomorphine ("Krokodil") abuse. The most frequently affected bone is the mandible, followed by the maxilla, combined necrosis of both jaws and bones in the midface area. The clinical findings include bone exposure, gingival recessions, suppuration, empty dental sockets, and fistula formation. Various examination methods have been reported, such as clinical and radiological assessment (radiographs, cone-beam computed tomography, etc.), histopathological evaluation, microbiological tests, and blood tests. The importance of C-telopeptide levels for the evaluation of the demarcation processes has also been underscored. Future studies are necessary to identify the distribution of the necrotic lesions according to the affected tissues/organs, and the possible correlation between the drug use period and the clinical findings. Different treatment modalities should also be investigated and compared.

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