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REVIEW ARTICLE

Craniomaxillofacial Injuries in Northwestern Ontario, Canada: A Narrative Review of Epidemiology, Mechanisms, Regional Challenges and Contemporary Management

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ABSTRACT

Introduction: Craniomaxillofacial (CMF) trauma represents a complex component of acute surgical care because injuries to the facial skeleton frequently occur in association with traumatic brain injury, cervical spine injury, ocular trauma, airway compromise and other multisystem injuries. The management of these injuries in Northwestern Ontario presents additional challenges related to the region's large geographic area, rural and remote populations, transportation distances and accessibility, environmental conditions and concentration of subspecialty trauma services in Thunder Bay.

Objective: To review the epidemiology, mechanisms, anatomical patterns, acute management, surgical treatment and prevention of CMF injuries in Northwestern Ontario, with consideration of the unique geographic and demographic characteristics of the region.

Methods: A narrative review of the available literature concerning CMF trauma in Northwestern Ontario was undertaken, supplemented by relevant Canadian and international literature addressing facial fracture assessment, imaging, multidisciplinary trauma management and prevention. Particular emphasis was placed on regional studies involving patients treated at Thunder Bay Regional Health Sciences Centre (TBRHSC).

Results: A 10-year retrospective review of 1077 CMF injuries managed at TBRHSC identified young adult males as the predominant injured population. Interpersonal violence was the leading mechanism of injury, with alcohol and drug use identified as important associated factors. Mandibular fractures were the most frequent fracture pattern, followed by malar and dentoalveolar injuries. A recurrent injury rate of approximately 7% was reported. Motor vehicle collisions represent the second most common mechanism, with wildlife-related collisions providing a distinctive regional pattern. Previous Canadian research demonstrated that occupants involved in moose-related collisions had a significantly greater risk of maxillofacial injury and fracture than occupants involved in other high-speed motor vehicle collisions.

Conclusions: CMF trauma in Northwestern Ontario reflects both the epidemiology of facial trauma seen elsewhere and mechanisms unique to northern Canada. Effective management requires a coordinated regional trauma system incorporating early stabilization, timely transfer, multidisciplinary surgical care, rehabilitation and injury prevention. Future research should update the epidemiology of CMF trauma in the region and evaluate changes in injury mechanisms, demographics, access to care and treatment outcomes over the past decade.

Keywords: craniomaxillofacial trauma; facial fractures; Northwestern Ontario; mandibular fracture; trauma; interpersonal violence; moose collision; rural trauma; Thunder Bay; injury prevention

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Introduction

Craniomaxillofacial trauma encompasses injuries involving the facial soft tissues, dentoalveolar structures and facial skeleton. These injuries frequently occur in association with traumatic brain injury, cervical spine trauma, ocular injury and other multisystem injuries.[1,2] The anatomical complexity of the face means that successful management requires restoration of airway function, occlusion, vision, facial projection, skeletal continuity and soft-tissue integrity while minimizing long-term functional and aesthetic morbidity.

The epidemiology of CMF trauma varies according to geography, socioeconomic circumstances, population demographics and mechanisms of injury. Assault, motor vehicle collisions (MVCs), falls, recreational activities and occupational injuries are consistently reported causes, although their relative importance varies between populations.[3]

Northwestern Ontario represents a particularly important environment in which to study CMF trauma. The region encompasses a vast geographic area with a relatively dispersed population and numerous rural, remote and Indigenous communities. Thunder Bay serves as the regional tertiary referral centre. TBRHSC is one of Ontario's designated trauma centres and functions as the lead trauma hospital for the Northwest Region. [4] The regional trauma system uses a hub-and-spoke model connecting TBRHSC with community hospitals, emergency medical services (EMS) and air and ground transport providers.

The largest published regional review evaluated 1077 CMF injuries treated at TBRHSC over 10 years.[5] The study demonstrated a predominance of young adult males, interpersonal violence as the leading mechanism and mandibular fractures as the most frequent skeletal injury.[5] Other regional publications have highlighted mechanisms that are particularly relevant to northern Canada, including collisions involving moose, snowmobile injuries and all-terrain vehicle (ATV) trauma.[6-8]

The purpose of this review is to synthesize the available regional evidence, incorporate contemporary CMF trauma literature, and identify priorities for future trauma care and research in Northwestern Ontario.

Materials and Methods

A narrative literature review was performed in August 2026. PubMed/MEDLINE and Google Scholar were searched using combinations of the following terms: *craniomaxillofacial trauma*, *maxillofacial trauma*, *facial fractures*, *mandibular fractures*, *dentoalveolar trauma*, *Northwestern Ontario*, *Thunder Bay*, *Ontario trauma*, *moose motor vehicle collision*, *snowmobile injury*, *ATV injury*, *rural trauma*, *remote trauma*, *telemedicine*, *trauma transfer* and *injury prevention*.

Peer-reviewed studies published between 2014 and 2026 were preferentially included for contemporary management and epidemiological information. Earlier publications were retained when they represented the principal Northwestern Ontario datasets or provided important historical information regarding regional mechanisms of injury. Relevant publications were identified through reference lists of included studies. Current information concerning the Northwestern Ontario trauma system was obtained from TBRHSC and Critical Care Services Ontario resources.[4]

Because the purpose was to provide a regional narrative review rather than a systematic review or meta-analysis, no formal PRISMA protocol or quantitative risk-of-bias analysis was undertaken.

REGIONAL TRAUMA SYSTEM

Thunder Bay Regional Health Sciences Centre provides specialized trauma care for Northwestern Ontario and is one of 11 designated trauma centres in Ontario.[4] (Figure 1) The Northwest Regional Trauma Network uses a hub-and-spoke model, with TBRHSC serving as the hub and 12 smaller community hospitals functioning as spokes working closely together with EMS, land and air-transport partners.

Figure 1. Trauma Hospitals in Ontario, CANADA

This organization is particularly relevant to CMF trauma. A patient with a facial fracture may initially present to a rural emergency department without immediate access to an oral and maxillofacial surgeon, plastic surgeon, ophthalmologist, neurosurgeon or other subspecialists. The initial objectives are therefore recognition of life-threatening injury, airway stabilization, hemorrhage control, appropriate imaging and timely communication with the receiving trauma centre.

The regional trauma program provides rural trauma education, including Rural Trauma Team Development Course training emphasizing systematic assessment, resuscitation, communication and transfer. TBRHSC also maintains regional critical-care and educational infrastructure designed to connect rural providers with tertiary expertise.[4]

Geography therefore becomes an important clinical variable. TBRHSC has described the Northwest catchment as an area approximately the size of France (Figure 2), with transportation by road, fixed-wing aircraft and helicopter required depending upon the location and clinical urgency.

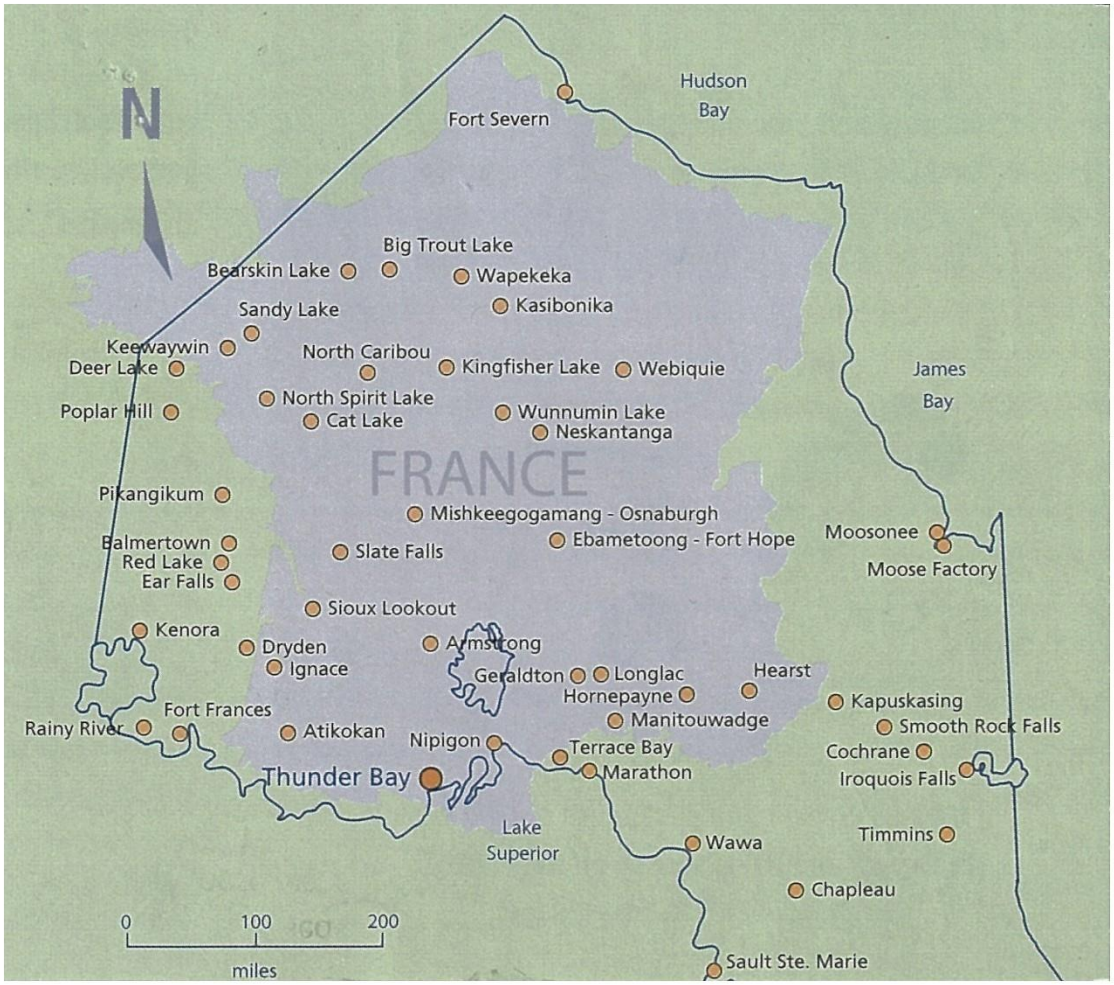


Figure 2. Northwestern Ontario with map of France (in gray)

EPIDEMIOLOGY OF CMF INJURIES

The regional cohort of 1077 CMF injuries remains the most important published epidemiological dataset specific to Northwestern Ontario.[5] As previously mentioned, males aged 18–25 years represented the largest injured population. Interpersonal violence was the leading mechanism, and alcohol and drug use were major cofactors.[5]

Mandibular injuries accounted for 29% of injuries, followed by malar fractures at 24% and dentoalveolar injuries at 10% and combinations of these fractures at 22%.[5] (Figure 3) Approximately 7% of patients sustained recurrent fractures.[5] The recurrence rate is clinically important because it suggests that a proportion of facial trauma represents repeated exposure to risk rather than isolated events.

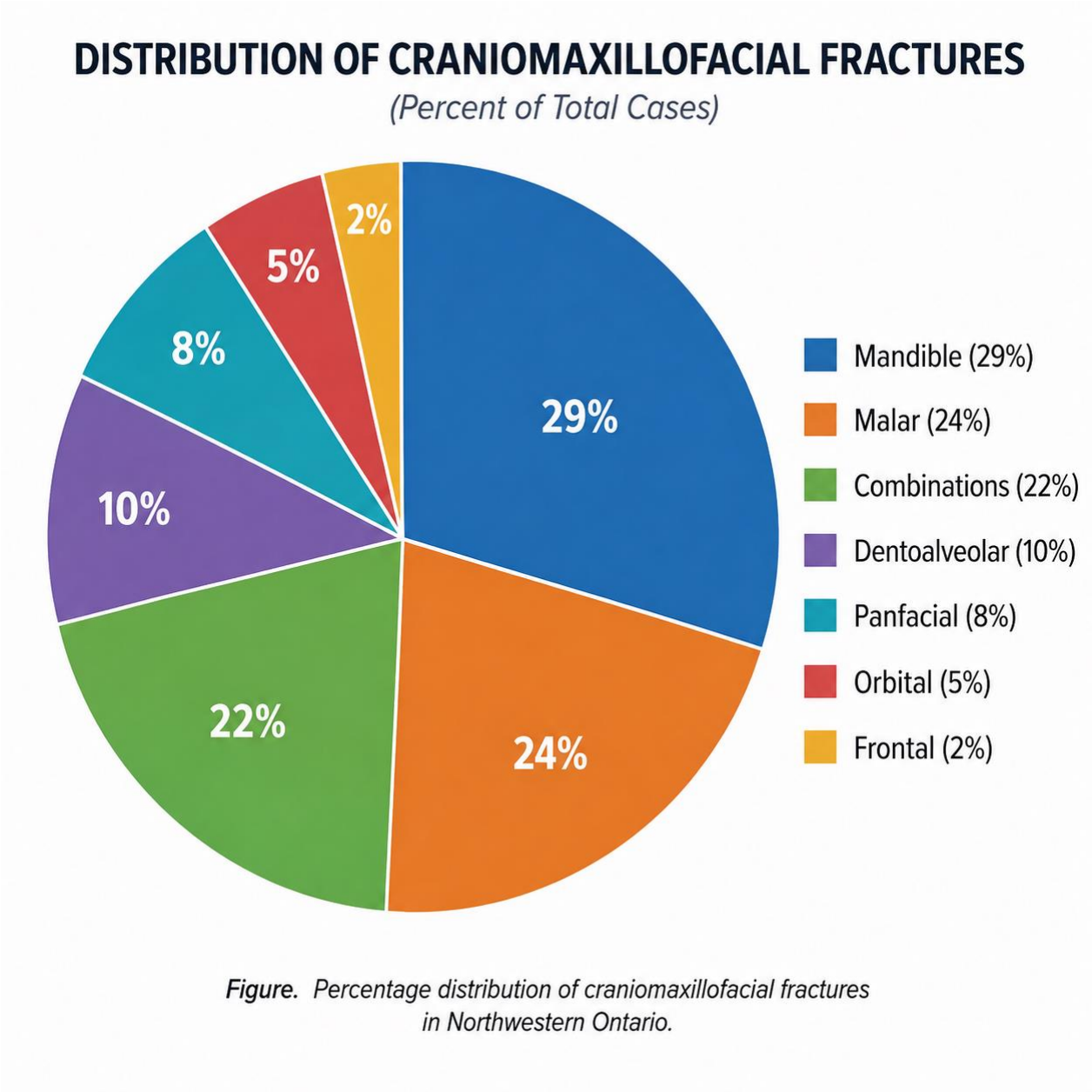


Figure 3. Distribution of Craniomaxillofacial fractures (N=1077)

The regional findings are broadly consistent with Canadian mandibular-trauma literature. A Canadian level I trauma-centre study identified assault as the most common mechanism of mandibular fracture, with 78% of patients being male and substantial proportions of fractures associated with alcohol or illicit drug use.

At the provincial level, Al-Dajani et al. examined Ontario emergency department and hospitalization data from 2004 to 2012. More than 1.45 million emergency department visits and 41,057 hospitalizations were attributed to maxillofacial injuries during the study period. Falls were the leading cause overall, and rural regions had higher rates of both emergency department visits and hospitalizations.[9] These findings are important when interpreting the Northwestern Ontario experience: the regional TBRHSC cohort represents patients reaching a tertiary trauma centre and may therefore differ substantially from the broader Ontario population. Thunder Bay Regional experiences an exceptionally high per-capita utilization load compared to southern urban centres, driven heavily by remote northern transfers and limited alternate community bed capacities.

Table 1. Principal Northwestern Ontario CMF trauma literature

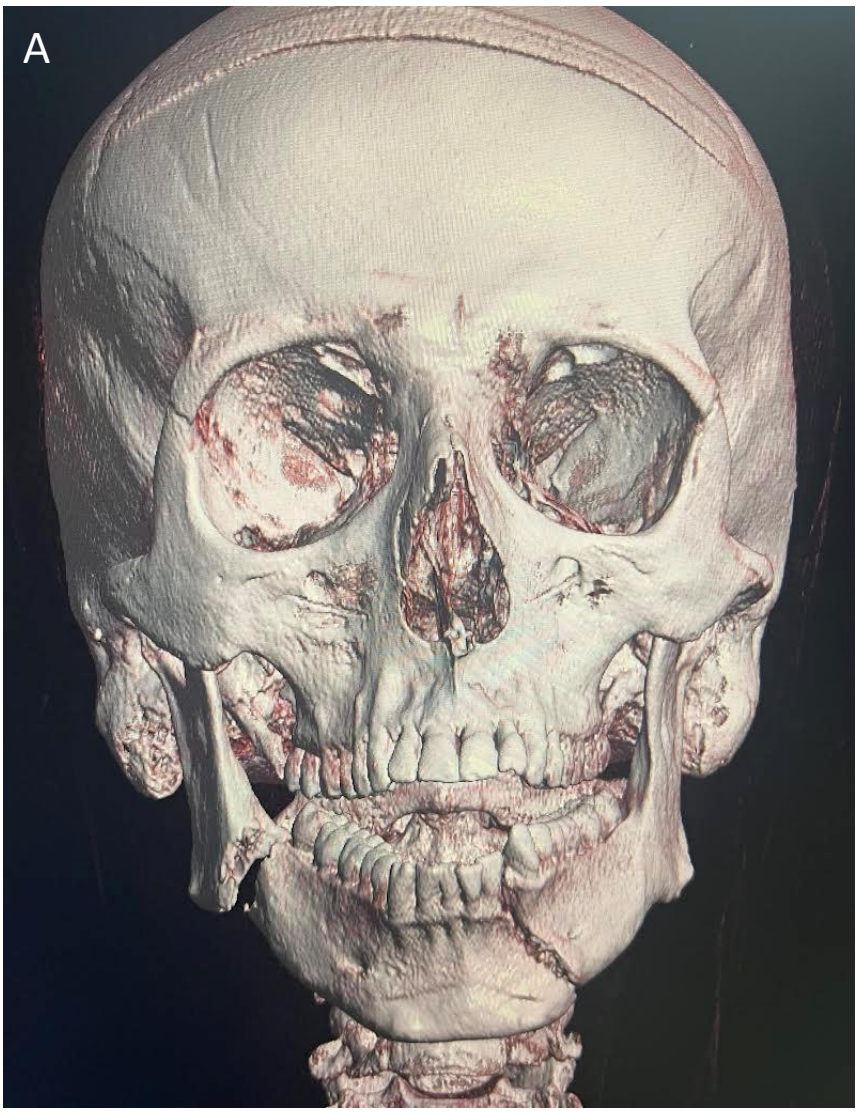
Study	Population/design	Principal findings	Regional significance
Pynn et al., 2003[6]	Regional moose/MVC report	Facial fractures associated with high-energy wildlife collisions	Identified a distinctive northern mechanism
Pynn et al., 2013[5]	1077 CMF injuries over 10 years	Young males predominated; interpersonal violence leading mechanism; mandible 29%, malar 22%, dentoalveolar 10%; recurrence 7%	Principal regional CMF epidemiological dataset
Pynn et al., 2005[7]	Moose/MVC case report and review	Severe facial and soft-tissue injury associated with moose collision	Demonstrated unique injury biomechanics
Pynn et al., 2010[8]	Regional clinical review	Mandibular, zygomatic and dentoalveolar injuries prominent; ATV, snowmobile and occupational trauma important	Demonstrated breadth of regional mechanisms
Al-Dajani et al., 2015[9]	Ontario administrative database	Falls leading cause overall; rural areas had higher injury rates	Provides provincial comparison
Hogg et al., 2000	2969 severely injured Ontario trauma patients	17% had maxillofacial fractures; MVCs predominated	Provides historical provincial trauma benchmark

Mechanisms of Injury

INTERPERSONAL VIOLENCE

Interpersonal violence was the predominant mechanism in the Northwestern Ontario cohort.[5] This pattern is consistent with Canadian mandibular-fracture data and with many North American populations.[10]

Assault-related injuries frequently involve the mandible, zygoma, orbit and dentoalveolar structures. (Figure 4a-d) Substance use may contribute both to exposure and injury severity. The 7% recurrent fracture rate in the regional cohort emphasizes the importance of secondary prevention, social intervention and appropriate follow-up.[5]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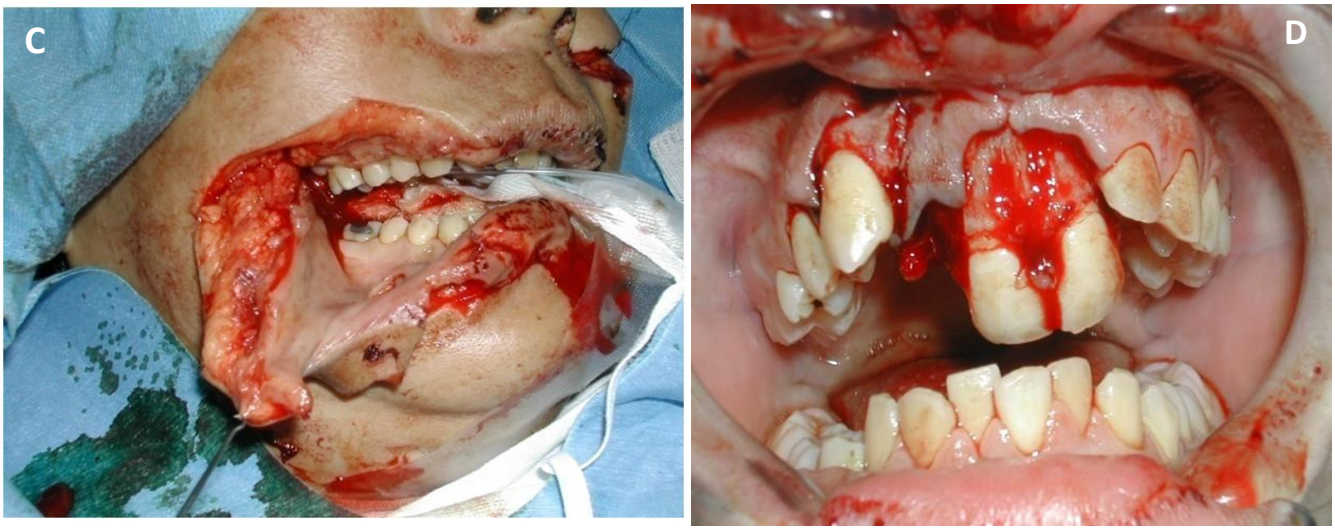

Figure 4. Interpersonal violence.

(a) Bilateral mandible fracture. Assault with a bat. Male vs Male

(b) Filet knife through sphenoid bone & posterior orbit. Assault. Girl vs Girl

(c) Extensive laceration. Assault with a broken bottle. Domestic violence

(d) Dentoalveolar fracture avulsion. Assault with a fist. Male vs Male

MOTOR VEHICLE COLLISIONS

Motor vehicle accidents remain an important cause of severe CMF trauma. Historical Ontario trauma-registry data demonstrated that MVCs accounted for approximately 70% of maxillofacial fractures among severely injured patients.[11] Head and neck injuries were the most common associated injuries.

Modern occupant-protection systems have altered the pattern and severity of facial trauma. Airbags and seatbelts reduce facial and cranial injury risk, although high-energy collisions continue to generate complex panfacial injuries. Northwestern Ontario is at the crossroads of Canada and has a high volume of semi-tractor traffic which is responsible for a significant number of MVCs.

WILDLIFE COLLISIONS

Moose-related MVCs represent a particularly distinctive mechanism in Northwestern Ontario. Pynn and colleagues described facial trauma associated with collisions on Highway 11/17 and emphasized the unusual biomechanics of these events.[6,7]

Comparative Canadian research found that occupants involved in moose collisions were 1.8 times more likely to sustain maxillofacial injury and 4.2 times more likely to sustain maxillofacial fractures than occupants involved in other high-speed MVCs.[11] Moose collisions were typically frontal and frequently resulted in windshield damage.[11] (Figure 5a-c) The occupants typically have midface, orbital and skull fractures requiring a lengthy combined neurosurgical and maxillofacial repair with an ICU admission.

Figure 5. Moose-motor vehicle
(a) Truck hood and windshield damage
(b) Skull and mid face fracture repair
(c) Road signage

The mechanism is related to the animal's height and mass. The vehicle may strike the animal's legs, causing the body to pass over the hood and impact the windshield (glass fragments) and roof, directing substantial kinetic energy toward the head and face.[11] These cases can be further complicated by the entrails, fur and feces from the animal in the wounds of the occupants.

SNOWMOBILE AND ATV TRAUMA

Snowmobile and ATV use represents another regional mechanism. Published Northwestern Ontario reports have described facial injuries resulting from snowmobile and ATV accidents, including complex midface fractures and associated extremity trauma.[8,12] (Figure 6a-c)

Figure 6. ATV vs tree accident

(a) Initial appearance in trauma unit
(b) CT scan 3D reconstruction pre-surgery
(c) CT scan 3D reconstruction post-surgery (Courtesy of Dr K. Cuddy)

These mechanisms are important because they combine high velocity, unpredictable terrain, limited immediate medical access and, in some cases, inadequate protective equipment. Prevention therefore requires both helmet use and behavioral interventions addressing speed, alcohol, drugs and risk-taking.

Anatomical Patterns and Clinical Management

MANDIBULAR TRAUMA

Mandibular fractures remain among the most common CMF injuries and were the most frequent injury in the Northwestern Ontario cohort.[5] Contemporary management emphasizes restoration of occlusion, mandibular continuity and function while minimizing complications such as malocclusion, infection, nonunion and neurosensory dysfunction.[13]

Open reduction and internal fixation is widely used for displaced fractures, although treatment must be individualized according to fracture site, displacement, soft-tissue injury, dentition and patient factors.[13] Three-dimensional imaging and computer-assisted planning are increasingly incorporated into complex cases.[13]

MIDFACE AND ORBITAL TRAUMA

Zygomaticomaxillary complex and orbital fractures may produce facial asymmetry, malar flattening, diplopia, enophthalmos, infraorbital nerve dysfunction and trismus. Orbital fractures require careful ocular assessment before definitive treatment. Contemporary orbital reconstruction increasingly incorporates three-dimensional planning, navigation, intraoperative imaging and patient-specific implants.[14]

PANFACIAL TRAUMA

Panfacial fractures require restoration of facial height, width and projection while maintaining or reconstructing occlusion. A systematic review of fixation sequencing suggested that bottom-to-top and outside-to-inside approaches frequently provide satisfactory results, although no universal sequence is appropriate for every patient.[15] Definitive repair may be delayed when associated intracranial, cervical or systemic injuries take priority.

AIRWAY MANAGEMENT

Airway compromise is one of the most immediate concerns in severe CMF trauma. Blood, edema, displaced teeth, tissue disruption and skeletal instability can make conventional intubation difficult. A systematic review of airway techniques in CMF trauma emphasizes individualized planning and familiarity with alternative techniques, including submental intubation and tracheostomy when appropriate.[16]

This issue has particular importance in Northwestern Ontario because patients may require prolonged stabilization before transfer and may initially be treated in facilities without CMF subspecialty coverage.

REGIONAL ACCESS AND TELEMEDICINE

The geographic distribution of Northwestern Ontario creates an access challenge that is fundamentally different from that of urban trauma systems. Remote communities may be separated from tertiary surgical services by several hundred kilometres. Research from remote Northwestern Ontario has demonstrated significant challenges in emergency response, including limited access to paramedic services and substantial transportation barriers.[18]

The regional trauma system has increasingly incorporated telemedicine and videoconferencing into critical-care support. Although direct evidence specific to CMF trauma in Northwestern Ontario remains limited, recent literature supports the potential value of telemedicine in maxillofacial trauma triage. A 2026 study of telemedicine-supported maxillofacial trauma management suggested that hub-and-spoke consultation may assist triage, reduce unnecessary transfers and improve integration between peripheral and tertiary centres.[19]

For Northwestern Ontario, potential applications include remote review of CT imaging, assessment of airway and soft-tissue injuries, triage of orbital trauma, determination of transfer urgency and postoperative follow-up.

Injury Prevention

The epidemiology of Northwestern Ontario CMF trauma provides several opportunities for prevention. Interpersonal violence prevention should address alcohol and substance use, social determinants of health and recurrent exposure to violence. Patients presenting with recurrent facial trauma represent an important population for intervention.

Road-safety initiatives should emphasize seatbelts, impaired-driving prevention, speed reduction and wildlife awareness. Moose-collision prevention is particularly relevant to northern highways. Driver education, roadside warning systems and wildlife-management strategies may contribute to reducing collision frequency and severity.

Snowmobile and ATV injuries require attention to helmet use, speed, alcohol and operator training. Occupational prevention is similarly important in industries involving forestry, mining, construction and heavy equipment.

The regional trauma program's emphasis on injury prevention, including STOP THE BLEED® education, illustrates the importance of extending trauma care beyond the hospital.[4]

Indigenous and Remote Communities

The original Northwestern Ontario CMF cohort reported a disproportionate burden of injury among First Nations patients.[5] Northwestern Ontario has 88/133 First Nations and Indigenous communities within the province of Ontario. This finding should be interpreted cautiously because it reflects the demographic and social circumstances of the historical study period and should not be interpreted as an inherent population characteristic.

More recent research emphasizes the substantial barriers faced by remote Indigenous communities in Northwestern Ontario, including distance, transportation limitations, limited emergency resources and the need for culturally appropriate healthcare.[18]

Future CMF research should therefore examine injury mechanisms and access to care using contemporary, community-informed approaches. Prevention programs should be developed collaboratively with Indigenous communities rather than imposed externally.

Future Research Priorities

The most important limitation of the Northwestern Ontario CMF literature is the absence of a contemporary regional epidemiological update. The principal 1077-patient cohort provides an invaluable historical baseline but does not establish whether the epidemiology of CMF trauma has changed during the subsequent decade.

A contemporary regional trauma registry should examine:

1. incidence and demographics of CMF trauma;
2. changes in interpersonal violence and substance involvement;
3. MVC and wildlife-collision patterns;
4. snowmobile and ATV injuries;
5. rural versus urban presentation;
6. Indigenous and remote-community access;
7. time from injury to definitive treatment;
8. transfer distance and mode;
9. operative versus nonoperative management;
10. complications and reoperation;
11. neurosensory and functional outcomes; and
12. long-term psychosocial outcomes.

The quality of the CMF trauma literature remains an additional concern. A contemporary assessment of published evidence found that much CMF trauma literature continues to rely heavily on retrospective studies and relatively low levels of evidence.[22] A prospective regional registry could therefore provide a valuable contribution to the Canadian trauma literature.

Conclusions

Craniomaxillofacial trauma in Northwestern Ontario represents an important regional healthcare burden characterized by both conventional and distinctive mechanisms of injury. The principal historical regional cohort demonstrated that young adult males were disproportionately affected, interpersonal violence was the dominant mechanism, and mandibular fractures were the most common skeletal injury.[5]

The region also presents unique trauma mechanisms, particularly moose-related MVCs, snowmobile accidents and ATV injuries. Wildlife collisions can produce a disproportionate burden of facial fractures because of their distinctive biomechanics.[11]

The geography of Northwestern Ontario presents an equally important challenge. Tertiary CMF expertise is concentrated in Thunder Bay, requiring effective coordination between rural hospitals, EMS, air transport and specialist services. The Northwest Regional Trauma Network provides an important infrastructure for addressing these challenges.

Contemporary CMF trauma management increasingly incorporates multidetector CT, three-dimensional planning, patient-specific implants, improved airway strategies and multidisciplinary reconstruction. Telemedicine may further improve regional triage and access to specialist expertise.

The next important step should be a contemporary epidemiological study of CMF trauma in Northwestern Ontario. Updating the original 1077-patient cohort would allow assessment of changing mechanisms, treatment patterns and outcomes and would provide evidence necessary for future trauma-system planning. Northwestern Ontario offers a unique natural setting in which to study the interaction between CMF trauma, rurality, remoteness, environmental hazards and regionalized surgical care.

Table 2. Regional mechanisms of CMF injury and prevention priorities

Mechanism	Typical CMF injury pattern	Regional considerations	Prevention priorities
Interpersonal violence	Mandibular, zygomatic, orbital, dentoalveolar	Young adult males; alcohol/substance association; recurrent injury	Violence prevention, substance-use intervention, social support
Motor vehicle collision	Panfacial, orbital, mandibular, midface	Long rural highways; high-energy collisions; winter conditions	Seatbelts, impaired-driving prevention, speed control
Moose/wildlife collision	Midface, orbital, frontal, mandibular	Large animal mass and high centre of gravity; windshield impact	Wildlife warning systems, driver awareness, speed reduction
Snowmobile	Midface, mandible, dentoalveolar, soft tissue	Seasonal; remote terrain; high velocity	Helmets, operator education, alcohol prevention
ATV	Zygomatic, orbital, midface, mandibular	Hunting, recreation and rural transportation	Helmets, training, speed control
Occupational	Facial laceration, orbital, mandibular and complex soft-tissue injury	Forestry, mining, construction and heavy equipment	PPE, workplace safety programs
Falls	Nasal, orbital, dentoalveolar, mandibular	Increasing importance with population ageing	Fall prevention and community programs

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