Patterns of facial trauma before and after legalization of marijuana in Denver, Colorado: A joint study between two Denver hospitals☆

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ABSTRACT

Introduction: The effect of marijuana on human health has been studied extensively. Marijuana intoxication has been shown to affect performance, attention span, and reaction time. The public health relationship between trauma and cannabis use has also been studied, with mixed conclusions. In this report, the effect of marijuana legalization on many aspects of facial trauma at two hospitals in Denver, Colorado is examined.

Methods: A retrospective review of the electronic medical records was undertaken. Mann-Whitney U tests were used to compare age of patients before and after legalization, and chi squared analyses were used to compare mechanism of injury, and fracture types before and after recreational marijuana legalization in Denver, Colorado. Geographical location of patients was also considered.

Results: No significant increase was found in race before and after marijuana legalization ($p = 0.19$). A significant increase in age was found before ($M = 39.54, SD = 16.37$), and after ($M = 41.38, SD = 16.66$) legalization ($p < 0.01$). Maxillary and skull base fracture proportions significantly increased following legalization ($p < 0.001$ and $p < 0.001$ respectively). No significant differences were seen in the proportion of patients who lived in urban and rural counties before and after legalization ($p > 0.05$).

Conclusion: Public health efforts should be directed towards educating residents and visitors of Colorado on the effects and toxicology of marijuana. More epidemiologic studies are needed for further assessment of the long-term effects of the legalization of marijuana on the population.

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1. Introduction

Marijuana (cannabis, pot) has been ingested by humans for thousands of years. Routes of ingestion include smoke inhalation and orally in foods, teas, lozenges or capsules. Cannabidiol (CBD) is the active compound in marijuana that activates the central nervous system limbic and paralimbic cortices [1]. CBD reduces autonomic arousal and feelings of anxiety. Marijuana use has been reported improve various health conditions including chronic pain, chemotherapy associated nausea and vomiting, anxiety and seizure disorders. Hyperemesis, dental caries, pulmonary disease, cancer, cardiovascular, and motor vehicle accidents have also been reported adverse effects [2].

Marijuana, when used with other drugs such as alcohol increases the euphoria caused by either drug alone, as well as its sedative effects [2]. Ingestion of marijuana and other drugs while operating machinery is an increasing concern in the United States, and has been found by toxicology screen in a high percentage of fatal motor vehicle accidents [3,4].

The legalization of recreational marijuana in Colorado was an incremental process starting with medical marijuana legalization in 2000, medical licensure and increased use in 2009, and then widespread recreational use in 2014. The public health effects of recreational marijuana use are only beginning to be explored. The burden of marijuana tourism on the health infrastructure in Colorado is also a valid concern to public health stakeholders. The state of Colorado has developed a framework to monitor the public health impact of marijuana use, while providing services to monitor and prevent negative impacts to public health [3]. Of specific concern to otolaryngologists and facial plastic surgeons is the effects of legalization of recreational marijuana use on patterns of facial fractures.

The effect of marijuana on human health has been extensively studied. Marijuana intoxication is known to affect performance, attention span, and reaction time [4]. Scientific epidemiological data on the effect of marijuana on facial trauma is mixed [5,6]. Several studies however, have shown a high prevalence of cannabis use among patients presenting to emergency rooms with various kinds of trauma [7,8]. A study of

maxillofacial fractures requiring surgical treatment between 2005 and 2010 found that 57 out of 394 patients were intoxicated at the time of injury. Of these, only 1 patient was noted to have used cannabis [9]. This study was conducted in Utrecht, Netherlands, where substance use is illegal but without active prosecution. In contrast, a French study in 2005 reported that cannabis was found in 8.8% of automobile crash fatalities (6700 incidents) [10].

Emergency room visits related to cannabis use appear to be discrepantly increasing among out of state visitors to Colorado than among Colorado residents since 2011, [11,12] possibly portending a need for more education and awareness of the effects of marijuana use on the individual and the public in general.

In this study, we explore whether the legalization of recreational marijuana in the state of Colorado has led to any changes in the patterns of facial fractures seen at two tertiary care Denver hospitals- Denver Health Medical Center, a level 1 trauma center; and University of Colorado Hospital, a level 2 trauma center. This study improves our understanding of the effects of marijuana legalization on facial fracture patterns, mechanisms of injury, and demographics of affected patients. These findings will prove to be important in public health education efforts aimed at monitoring and preventing negative effects on the population.

2. Materials and methods

Institutional Review Board approval was obtained from the Colorado Multiple Institutional Review Board (COMIRB), and a retrospective review of the electronic medical record (EPIC, Verona, WI and Siemens Enterprise Document Management System, Malvern, PA) was undertaken. From January 1, 2012 to December 31, 2015, all patients presenting to the University of Colorado Hospital (UCH) and Denver Health Medical Center (DHMC) with bony facial trauma were identified. All clinical notes and operative records were carefully reviewed to collect numerous data points pertinent to the study. Abstracted data was organized in a Redcap database (Vanderbilt University, Nashville, TN). Facial fracture data included fracture type (mandible, nasal, frontal, zygomaticomaxillary complex, Lefort I, II, III, orbit and palate), date of injury and mechanism of injury. Demographic data, patient history of marijuana use, toxicology screen results, and patient home address zip code, were obtained and used as comparative variables before and after legalization of marijuana. Inclusion criteria were patients between the ages of 18–100 years old with bony trauma to the head or face. Those not meeting these criteria or with remote facial fractures that did not present to hospital acutely were excluded.

2.1. Statistical analysis

Continuous variables (age) were expressed as the mean (standard deviation, SD) and were compared using Mann-Whitney U tests. Categorical variables (race, mechanism, pattern of injury) were analyzed as counts and proportions. An independent samples t-test was performed to compare mean patient age before marijuana legalization. To examine the relationship between mechanism of fracture and marijuana legalization, a chi-square test of independence was performed. Individual chi-square tests for equality of proportions were also performed to examine the effect of marijuana legalization status on the proportion of patients with each specific fracture type. An alpha level of 0.05 was used for all statistical tests. Patient counties were designated as urban or rural according to 2014 designations by the Colorado Rural Health Center of the State Office of Rural Health. Proportions of rural and urban patients, and in-state and out of state patients before and after marijuana legalization were examined using a chi-square test. All analyses and figure generation were performed in R 3.2.4. (R Foundation for Statistical Computing, Vienna, Austria) Figures were generated using the ggplot (Springer-Verlag New York, USA) and RColorBrewer packages (Pennsylvania, USA). The Mann-Whitney U test was implemented as an alternative to the unpaired two-sample t-test because not all underlying assumptions of the t-test could be met. Although the t-test is generally robust to non-normal distributions, the Mann-Whitney U Test makes fewer assumptions about the data, and is thus more conservative. Therefore, since some comparisons often had small sample sizes or samples that did not follow normal distributions, the Mann-Whitney U Test was selected for use in these comparisons. In cases where the data did meet the underlying assumptions of the t-test, the t-test was implemented to identify significant differences in means. Chi-square tests of independence were used to test the relationship between mechanism of fracture and marijuana legalization status. This test was selected due to the large sample size (with expected frequency counts for each cell of the contingency table > 5), independence of observations, and the data being a simple random sample. Finally, since the relationship between marijuana legalization and the proportions of specific fracture types was of interest, individual chi-square tests for equality of proportions were implemented.

3. Results

3.1. Patient characteristics

A total of 2164 patients who presented to the University of Colorado Hospital and Denver Health Medical Center met inclusion criteria and were included in this study. Patient demographic data are displayed in Table 1. No significant increase was found in race (p = 0.19) (Fig. 3). A significant increase in age was found before (M = 39.54, SD = 16.37), and after (M = 41.38, SD = 16.66) legalization (p = 0.01). The distribution of patient age displayed graphically in Fig. 4.

3.2. Fracture patterns

Individual mechanisms of facial fracture were not significantly affected by the legalization of marijuana, p = 0.76. When individual fracture types were analyzed, both maxillary and skull base fracture

Table 1
Demographic data.

Characteristic	Total (n = 2164)	UCH (n = 1118)	DH (n = 1046)
Patients, n (%)			
Before legalization	1095 (50.6)	531 (47.5)	564 (53.9)
After legalization	1069 (49.4)	587 (52.5)	482 (46.1)
Males, n (%)			
Males	1601 (74)	752 (67.3)	849 (81.2)
Females	562 (26)	365 (32.7)	197 (18.8)
Unknown/NA	1 (0.05)	1 (0.09)	0 (0)
Age, mean years (sd)	40.4 (16.5)	40.09 (17.0)	40.8 (16.1)
Race, n (%)			
White	1116 (51.6)	554 (49.6)	562 (53.7)
Hispanic	593 (27.4)	258 (23.1)	335 (32)
Black	330 (15.3)	223 (20)	107 (10.2)
Asian	34 (1.6)	24 (2.2)	10 (1)
Native American	18 (0.8)	5 (0.5)	13 (1.2)
Other/NA	97 (5.2)	55 (4.8)	19 (1.8)
Method of fracture, n (%)			
Car accident	383 (17.7)	112 (10)	271 (25.9)
Bike accident	189 (8.7)	45 (4)	144 (13.8)
Altercation	852 (39.4)	505 (45.2)	347 (33.2)
Fall	464 (21.4)	283 (25.3)	181 (17.3)
Sports injury	88 (4.0)	75 (6.7)	13 (1.2)
Work injury	36 (1.7)	20 (1.8)	16 (1.5)
Other/NA	152 (7.0)	78 (7)	74 (7.1)
MJ positive, n (%)			
Positive	133 (6.2)	90 (8.1)	43 (4.1)
Negative	109 (5.0)	101 (9)	8 (0.8)
Unknown/NA	1922 (88.8)	924 (82.9)	995 (95.1)
Resident/out of state, n (%)			
Resident	2064 (95.4)	1077 (96.3)	987 (94.4)
Out of state	82 (3.8)	36 (3.2)	46 (4.4)
Unknown/NA	18 (0.8)	5 (0.5)	13 (1.2)