Evaluating the Impact of Raised Median Installations

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Abstract: Traffic volumes and congestion across the state of Utah and the throughout the nation continue to increase as cities feel the effects of a growing population. A large portion of the growth that is occurring has a direct impact on arterial streets placing greater emphasis on implementing access management principles and techniques to help alleviate safety concerns associated with access to these streets. As traffic volumes grow there comes the need to identify ways in which safety on the arterial streets can be improved. One such methodology is the installation of raised medians. To evaluate the impacts of the installation of raised medians on arterial streets, the Utah Department of Transportation (UDOT) in conjunction with a research team at Brigham Young University (BYU) performed a safety evaluation on arterial streets in which raised medians had been installed. This evaluation utilized a geographic information system (GIS) enabled web delivered data almanac that allowed researchers the opportunity to establish filters to sort crash data, identify high crash locations, and evaluate crash trends. The objective of this paper is to summarize the safety impacts of raised median installation by investigating crash data at one of several corridors across the state of Utah where raised medians have been implemented. The results of this paper are expected to provide direction and guidance to engineers and planners on the safety benefits of access management techniques specific to the state of Utah.

INTRODUCTION

As the population in the state of Utah continues to grow, traffic volumes and congestion continue to increase. A large portion of the growth that is occurring in the state of Utah and across the country has a direct impact on arterial streets, thus placing greater emphasis on implementing access management principles and techniques to help alleviate safety concerns associated with access to arterial streets. As traffic volumes grow there comes the need to identify ways in which safety on the arterial streets can be improved. One such methodology is the installation of raised medians.

The Utah Department of Transportation (UDOT) in conjunction with a research team at Brigham Young University (BYU) performed an evaluation of arterial safety on streets in which raised medians had been installed in an effort to evaluate the impacts of the installation of raised medians on arterial streets. This evaluation utilized a geographic information system (GIS) enabled web delivered data almanac that allowed researchers the opportunity to establish filters to sort crash data, identify high crash locations, and evaluate crash trends (Schultz and Lewis 2006).

The objective of this paper is to summarize the safety impacts of raised median installation by investigating crash data at one of several corridors across the state of Utah where raised medians have been implemented. To accomplish this objective and to provide the reader with background information on raised median installation and other access management criteria utilized in the state of Utah, this paper is organized according to the following sections: 1) access management in the state of Utah, 2) the data collection process used to evaluate the impact of raised median installations in the state, 3) analysis results for one arterial corridor with reference to other locations analyzed, and 4) conclusions as a result of the research.

ACCESS MANAGEMENT IN UTAH

UDOT has an obligation and responsibility to preserve and maintain the state highway system. UDOT is also responsible for ensuring that the state highway system meets regional and local transportation needs. When proper care is not taken with regards to access management, the traveling public is exposed to higher crash rates and other hazards.

Access management principles in the state of Utah are formalized in *Administrative Rule R930-6: Accommodation of Utilities and the Control and Protection of State Highway Rights of Way* (UDOT 2003). The Administrative Rule is provided to establish and formalize the management of access on the state highway system. Property owners who own land adjacent to state highways maintain the right to have reasonable access to their land. In the Administrative Rule, standards are established to balance the need of owners for reasonable access to land with the need to preserve the smooth flow of traffic on the state's highways. By implementing the Administrative Rule, UDOT works to prevent congestion and traffic crashes and improve public safety. The Rule includes techniques to "limit the number of conflict points at driveway locations, separate highway conflict areas, reduce the interference of through traffic, space at-grade signalized intersections, and provide for adequate on-site circulation and storage" (UDOT 2003).

The Administrative Rule was established for statewide implementation in an effort to ensure uniform and consistent application of the access management standards. To facilitate the statewide implementation of these standards, road segments have been categorized into "classifications of highways that have similar traffic movement purposes and objectives" (UDOT 2003). Every segment of state highway has been assigned one of nine highway classifications summarized in Table 1.

Table 1. State Highway Access Management Classifications (UDOT 2003)

Category Assignment		Description
1	I	Freeway/Interstate
2	S-R	Statewide Rural
3	S-U	Statewide Urban
4	R-R	Regional Rural
5	R-UF	Regional Urban Fluid
6	R-US	Regional Urban Static
7	C-R	Community Rural
8	C-U	Community Urban
9	O	Other

UDOT works closely with property owners and local governments in making access management decisions. In order to obtain access to a state highway system, property owners must apply for a permit through UDOT. Administrative employees look at each application and "review the balance of private property rights of reasonable access versus the public need to preserve the smooth flow of traffic on the State Highway system" (UDOT 2003). An access permit is required to construct, modify, relocate, or close a vehicular access that connects to the state highway right-of-way. Property owners must follow standards specified by the Administrative Rule in the design and spacing of driveway accesses as outlined in Table 2.

In addition to street and access spacing requirements, the Administrative Rule contains information on the installation of raised medians. Furthermore, a research study performed at BYU in 2004 evaluated raised medians as a safety improvement in the state of Utah. A procedure was developed that allows state engineers to identify the need for a raised median on a specific roadway and to make decisions on median installation (Saito et al. 2005). The research outlined in this paper continued the evaluation of safety on raised median installation in the state of Utah (Schultz and Lewis 2006).

Table 2. State Highway Access Management Standards (UDOT 2003)

Category		Minimum Signal Spacing (feet)	Minimum Street Spacing (feet)	Minimum Access Spacing (feet)	Minimum Interchange-to-Crossroad Access Spacing (feet)		
					to 1st R-in R-out "A"	to 1st Intersection "B"	from last R-in R-out "C"
1	I	Interstate/Freeway Standards Apply					
2	S-R	5,280	1,000	1,000	1,320	1,320	1,320
3	S-U	2,640	No Unsignalized Access Permitted		1,320	1,320	1,320
4	R-R	2,640	660	500	660	1,320	500
5	R-UF	2,640	660	350	660	1,320	500
6	R-US	1,320	350	200	500	1,320	500
7	C-R	1,320	300	150	Not Applicable		
8	C-U	1,320	300	150			
9	O	1,320	300	150			

Minimum interchange crossroad access spacing standards “A”, “B”, “C” are defined as follows:

1. Standard “A” refers to the distance from the interchange off-ramp gore area (point of widening) to the first right-in/out driveway intersection.
2. Standard “B” refers to the distance from the interchange off-ramp gore area (point of widening) to the first major intersection.
3. Standard “C” refers to the distance from the last right-in/out driveway intersection to the interchange on-ramp gore area (point of widening).

DATA COLLECTION

Several locations where access management techniques had previously been installed were chosen for analysis as part of the research project. The access management techniques implemented at these locations consisted primarily of raised median installations, however, driveway density data was also collected, indicating some locations where driveway consolidation had occurred.

To analyze data before and after median installation, the year in which the median was installed had to be determined. To determine the years that the raised medians were installed, the UDOT Roadview Explorer tool maintained by the Photolog Section of the Systems Planning and Programming Division at UDOT was utilized. To determine the year of installation, video of the state road under evaluation was viewed for past years until the raised median was identified in the photolog. Oftentimes the photolog showed construction during the year of installation, with full median the following year. Other means of determining the year of installation can also be used including a search of project files or interviews with region traffic or field engineers.

A summary of the corridors that were selected for analysis is shown in Table 3. The sites were divided into two groups: 1) analysis sites and 2) control sites. Control sites were selected at locations where raised medians had not been installed, but where conditions were similar to the analysis sites. A summary of each site is provided including the state route, county, the year the median was installed (if applicable), the length of the study corridor, the access points per mile for the installation year, and the access points per mile for 2005 (Schultz and Lewis 2006).

Table 3. Summary of Corridors in the Analysis

	Location	State Route	County	Year Installed	Length (miles)	Access[a] Points/Mile in Installation Year	Access[a] Points/Mile in 2005
Analysis Sites	University Parkway	265	Utah	2002	0.77	23.4	18.2
	Alpine Highway	74	Utah	2002	1.90	8.9	8.9
	State St.	89	Salt Lake	1994	0.50	16.0	22.0
	400/500 South	186	Salt Lake	2001	2.06	74.3	73.3
	300 West	89	Salt Lake	1999	0.30	26.7	26.7
	Redwood Road	68	Salt Lake	1994	0.73	37.0	27.4
Control Sites	700 East	71	Salt Lake	2002	0.60	N/A[b]	101.7
	12300 South	71	Salt Lake	2004	0.90	N/A[b]	34.4
	Redwood Road	68	Salt Lake	N/A[b]	0.50	N/A[b]	24.0
	St. George Blvd.	34	Washington	2006	1.75	N/A[b]	93.1
	SR 36	36	Tooele	2005	1.00	N/A[b]	19.0

[a] Access points include both directions of travel along the corridor.
[b] N/A - Not Applicable

Once the data collection sites were identified, the next step in the analysis was to obtain and evaluate before and after crash data from the raised median corridors. Crash records were extracted from the UDOT web-delivered crash data almanac. Valuable crash statistics for all of the roads on the State Highway system are available from this tool. The crash data almanac allows for rapid retrieval and analysis of crash data. The data almanac includes historic information for crashes dating back to 1992. The most recent crash data in the system at the time of the research was for calendar year 2004. The crash data almanac is a limited access password protected web-delivered tool. As such, users must be authorized by UDOT to gain access to the system.

According to the *Data Almanac User's Manual*, the system is designed to enhance the analysis of the data in a number of ways. Four of these include (Anderson et al. 2005):

1. Custom tables and reports are created with only selected parameters, leaving off unneeded data. This simplifies the analysis by focusing on what is important.
2. Placing the data on a "smart map" allows the researcher to visually identify hot spots or deficient areas. The analysis can be further refined by extracting information from the map as needed.
3. Information extracted through a series of queries from different data sources can be saved into a single spreadsheet for analysis. For example, wet weather crashes, skid index, and AADT could be acquired for a site from three different databases.
4. Researchers will have more time to analyze the data since it takes less time to gather and compile the information.

Crash analysis can be a very useful tool in the evaluation of the safety conditions of a highway. The number, type, and severity of crashes can lead to greater understanding of the causes of crashes on a roadway. This, in turn, can lead to effective solutions and ideas for improvements that can reduce crashes and improve safety. Crash analysis can be used to evaluate the impacts of roadway safety improvements that are already in place by analyzing before and after crash statistics. These types of studies can help identify effective safety improvements.

In order to estimate the safety benefits of access management techniques, a set procedure was established to collect crash data. Several types of analysis were utilized to determine the impact of raised median installations including segment analysis, intersection analysis, collision type analysis, and crash severity analysis. In the "Fixed Segment Analysis" option, for example, crashes are reported over short intervals of the segment being studied. The user is able to identify the route and years to be analyzed, while also determining the length of interval to evaluate. Any length of interval can be chosen depending on how specific the desired analysis needs to be with a default length of one-tenth-mile. The user can also specify the number of accidents to be used as a cutoff value for the search. The default for this entry is a zero (0) to satisfy the search requirements and identify all segments on the corridor. The "Fixed Segment Analysis" search produces an output table like the one illustrated in Figure 1. The table lists each one-tenth-mile interval and the corresponding number of crashes that occurred on that interval for the desired years. Overall crash rates (crashes per million vehicle miles traveled) and fatality rates (deaths per hundred million vehicle miles traveled) are also calculated and reported by the crash data almanac using 2004 AADT volumes (Schultz and Lewis 2006).

Each of the analysis types (i.e., segment analysis, intersection analysis, collision type analysis, and crash severity analysis) were evaluated for the sites identified previously. A summary of the results of one analysis site are provided in the following section.

Accident Search Results

Route:	0186	**Milepoint:**	5.5 - 7.59
Interval:	0.1	**# of Accidents:**	0

Route	Milepoint Interval	# of Accidents	Accident Rate	Fatality Rate
0186	5.50 - 5.60	6	7.37	0.00
0186	5.60 - 5.70	10	12.26	0.00
0186	5.70 - 5.80	3	3.68	0.00
0186	5.80 - 5.90	5	6.13	0.00
0186	5.90 - 6.00	2	2.45	0.00
0186	6.00 - 6.10	9	11.04	0.00
0186	6.10 - 6.20	4	4.91	0.00
0186	6.20 - 6.30	9	11.04	0.00
0186	6.30 - 6.40	1	1.23	0.00
0186	6.40 - 6.50	6	8.19	0.00
0186	6.50 - 6.60	5	6.83	0.00
0186	6.60 - 6.70	0	0.00	0.00
0186	6.70 - 6.80	3	3.53	0.00
0186	6.80 - 6.90	2	2.35	0.00
0186	6.90 - 7.00	6	7.06	0.00
0186	7.00 - 7.10	9	10.59	0.00
0186	7.10 - 7.20	1	1.18	0.00
0186	7.20 - 7.30	4	4.71	0.00
0186	7.30 - 7.40	2	1.86	93.01
0186	7.40 - 7.50	0	0.00	0.00
0186	7.50 - 7.60	2	1.86	0.00
				Total Records: 21

Figure 1. Example table of results from the "Fixed Segment Analysis" search.

ANALYSIS RESULTS

This paper will focus on the analysis results for the University Parkway (SR 265) corridor in Utah County. University Parkway extends from Geneva Road on the west side of Interstate 15 to 900 East in Provo. University Parkway is a heavily-traveled six-lane arterial that connects the two major universities in Utah County; Utah Valley State College (UVSC) and BYU. A raised median was installed on University Parkway in Orem in 2002 between 400 West and 200 East. Prior to the raised median installation, University Parkway had a painted median that separated the three lanes of traffic in each direction. This segment was chosen for analysis due to the high traffic volumes (2004 AADT of 39,235) and the high number of access points along the corridor (UDOT 2005). The raised median consists of a concrete curb with sections of landscaping as shown in Figure 2 (Schultz and Lewis 2006).

Figure 2. Raised median on University Parkway near 400 West intersection. (photo by Jeff S. Lewis)

The following section summarizes the crash data for this roadway segment for the periods before and after installation of the raised median. The before period includes the years from 1999 to 2001, while the after period includes the years from 2003 to 2004. Table 4 summarizes the before and after crashes on University Parkway including crash rates, fatality rates, a summary of access points and segment length data, as well as weighted average AADT data for each period. Figure 3 displays the crash rates at one-tenth-mile intervals for this segment of University Parkway. Figure 4 displays the intersection crash rate for all signalized intersections along the segment. Figure 5 illustrates the collision types on University Parkway by percentage of total crashes. Figure 6 shows the severity of crashes on University Parkway by percentage of total crashes. Finally, Table 5 shows the cost of crashes per severity type and the total cost of crashes on University Parkway for both the before and after periods (Schultz and Lewis 2006).

Table 4. Crash Data and Access Point Density for University Parkway (Schultz and Lewis 2006)

	Before (1999–2001)	**After (2003–2004)**
Crashes Per Year	62.7	97.5
Crash Rate (Crashes/MVMT[1])	6.37	9.13
Fatality Rate (Fatalities/100 MVMT[1])	4.75	0.00
Access Points	18	14
Length of Segment (mi.)	0.77	0.77
Access Points per Mile	23.4	18.2
Average Annual Daily Traffic (AADT)[2]	34,978	37,985

[1]MVMT = Million Vehicle Miles Traveled
[2]AADT is a weighted average for the segment

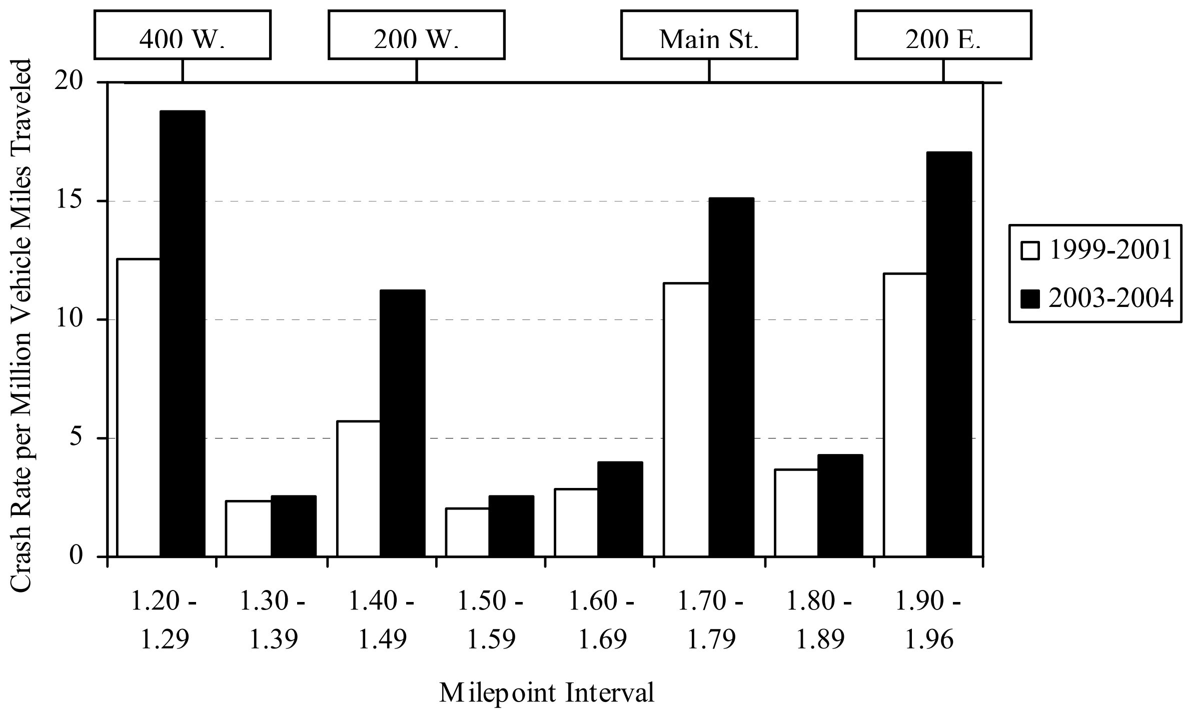

Figure 3. Crash rates for one-tenth-mile intervals of University Parkway (Schultz and Lewis 2006).

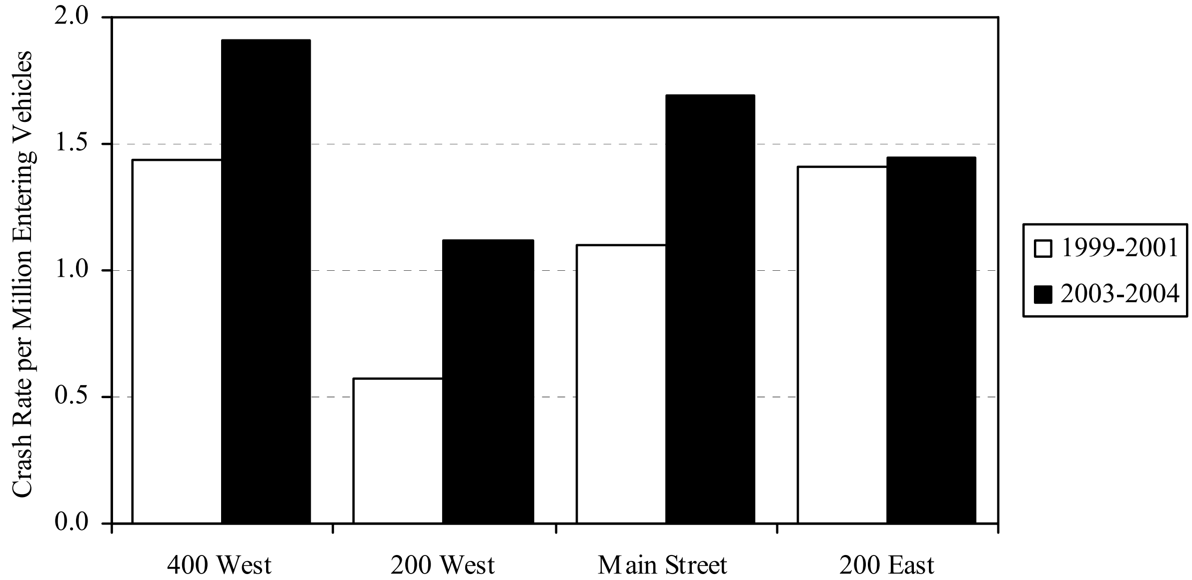

Figure 4. Intersection crash rates on University Parkway (Schultz and Lewis 2006).

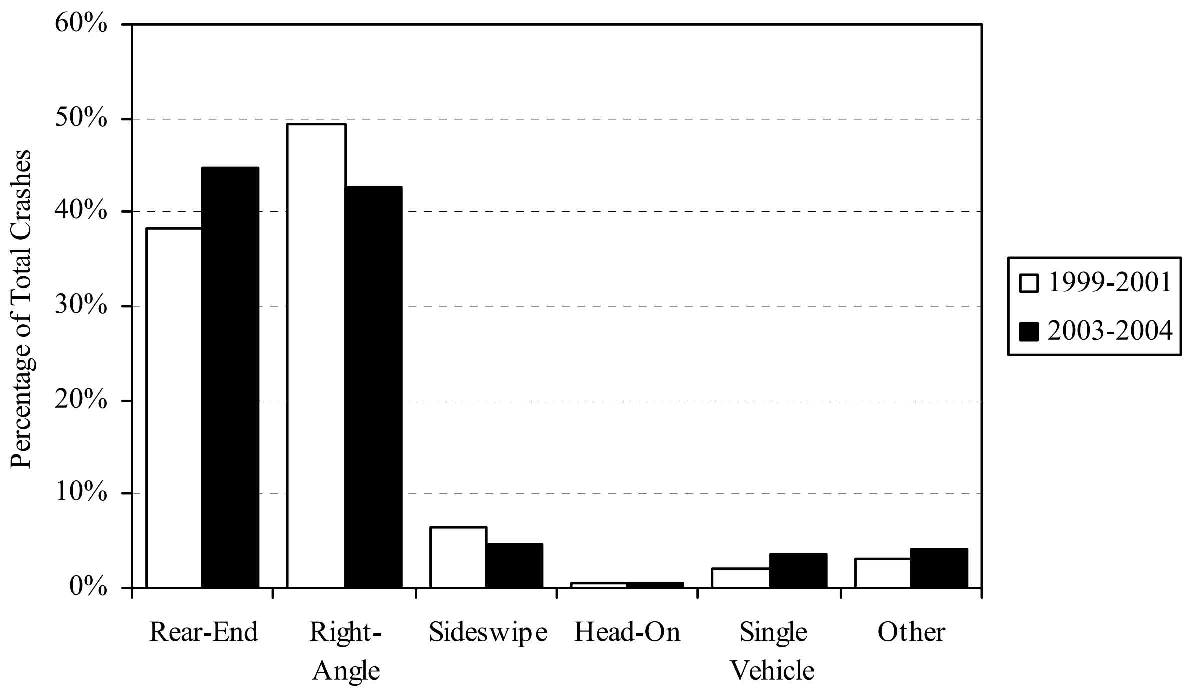

Figure 5. Collision types on University Parkway by percentage of total crashes (Schultz and Lewis 2006).

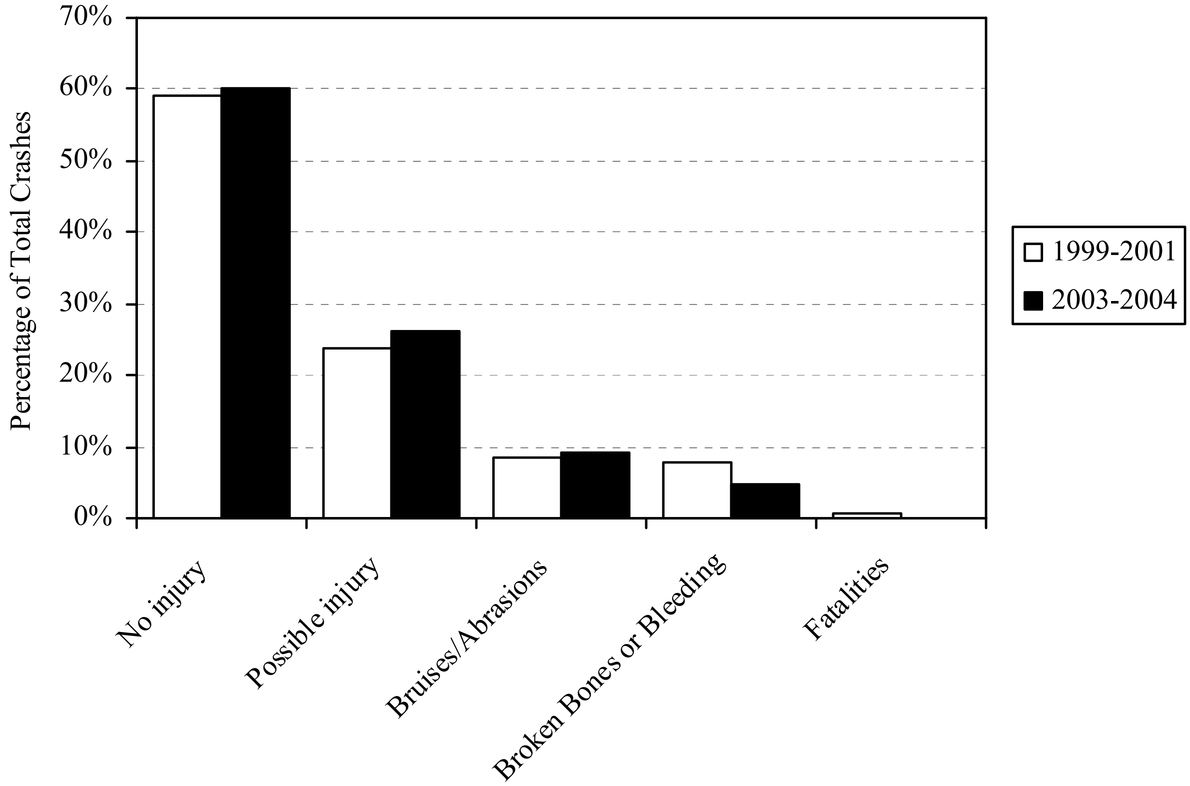

Figure 6. Severity of crashes on University Parkway by percentage of total crashes (Schultz and Lewis 2006).

Table 5. Cost of Crashes on University Parkway (Adapted from Schultz and Lewis 2006)

Crash Severity	Unit Cost	Before (1999–2001)	After (2003–2004)
No Injury	$ 4,500	$ 499,500	$ 526,500
Possible Injury	$ 25,000	$1,125,000	$1,275,000
Bruises/Abrasions	$ 48,000	$ 768,000	$ 864,000
Broken Bones or Bleeding Wounds	$ 228,000	$3,420,000	$2,052,000
Fatalities	$2,720,000	$2,720,000	$ 0
Total Cost of Crashes		**$8,532,500**	**$4,717,500**
Cost of Crashes Per Year		**$2,844,167**	**$2,358,750**

As shown in the analysis results, the crash rate for this segment of University Parkway increased after installation of the raised median from 6.37 to 9.13 crashes per MVMT, a change of 43 percent. The fatality rate, however, was reduced from 4.75 to 0.00 fatalities per 100 MVMT. The average AADT for the segment increased from 34,978 to 37,985 vehicles per day, an increase of 9 percent. This corridor is an area of rapid growth and a hot-spot for retail development, which contributes to a reduction in the level of service throughout this segment and at the signalized intersections, which may be causing crash rates to increase. The analysis results further show that the crash rate increased at each of the one-tenth-mile intervals and at the signalized intersections. Increases in crash rates at the signalized intersections may be caused by the fact that the raised medians force all left-turn movements to the signalized intersections.

Although the crash rates have increased along the corridor, the distribution of such crashes was changed from the before period to the after analysis period. Before the raised medians were installed, 50 percent of all the crashes were right-angle crashes. After the raised median installation, however, right-angle crashes made up only 43 percent of all crashes and were no longer the most common type of collision on this segment of University Parkway. It was anticipated that right-angle crashes may have decreased due to the reduction in left turns created by the raised medians. The changes in crash type also led to a redistribution of crash severity. Figure 6 illustrates that the no injury, possible injury, and bruises/abrasions crashes all increased slightly as percentages of total crashes. The broken bones/bleeding and fatalities crashes, however, both decreased as percentages of total crashes. These findings reflect the decrease in the more serious collision types. For example, right-angle and head-on crashes typically result in more severe crashes than do rear-end crashes. Since the percentage of right-angle crashes decreased on University Parkway, it is logical that the percentage of more severe crashes decreased as well. This result was found at nearly all of the analysis sites where raised medians had been installed. Because of the reduction in severity of crashes, the total cost of crashes per year also decreased. The more severe crashes are much more costly than the less severe crashes. Since the more severe crashes decreased between the before and after periods, the total cost of crashes per year decreased by 17 percent (Schultz and Lewis 2006).

The results of the data collected at the remaining analysis sites showed similar results. Although the majority of the corridors did not experience an overall reduction in crash rates, the severity of crashes was reduced in nearly every instance as a percentage of total crashes. The reduction in the severity of crashes led to an overall reduction in crash costs, thus providing justification for the installation of the raised median. At the control sites, the crash severity was not necessarily reduced, thus leading to an increase in overall costs of crashes per year. A summary of the overall changes in traffic characteristics at all locations is provided in Table 6. More detail on the overall analysis results and conclusions can be found in the literature (Schultz and Lewis 2006, Schultz et al. 2007).

CONCLUSIONS

The results of the study show that although access management techniques (e.g., raised medians) may not reduce overall crash rates in all instances, other safety improvements were observed that proved that the installation of raised medians are an effective safety tool in this application. Generally, fatality rates and severity of crashes decreased at the analysis sites evaluated after installation of the raised median, which was anticipated to be a direct result of the change in the predominant types of collisions. Rear-end and single-vehicle crashes generally increased, while right-angle crashes decreased as a result of the raised median installation. The reduction in right-angle crashes directly resulted in a lessening of the severity of crashes and improved the safety on the roadways where raised medians were installed. This also resulted in a reduction in the fatality rate. In general, the no injury crashes increased and the more severe crashes involving injuries and fatalities decreased as percentages of total crashes. The results show that, in general, a safer and less costly roadway is created by the installation of raised medians at the analysis sites. It is important to note that the results of this study are site specific and more research is required to establish more specific and transferable safety benefits.

Table 6. Overall Changes in Traffic Characteristics at All Locations (Schultz and Lewis 2006)

		Crash Rate	Fatality Rate	Access Points per Mile	AADT	Total Cost of Crashes per Year
Analysis Sites	University Parkway	●	○	○	●	○
	Alpine Highway	○	—	—	○	●
	State Street	●	○	●	●	○
	400/500 South	●	●	○	○	○
	300 West	●	—	—	○	○
	Redwood Road	○	—	○	●	○
Control Sites	700 East	○	●	—	○	●
	12300 South	●	●	—	●	●
	Redwood Road	○	○	—	●	○
	St. George Blvd.	●	●	—	○	●
	SR 36	○	—	—	●	●

"●" indicates an increase
"○" indicates a decrease
"—" indicates no change

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