Status of Tooth Loss and Denture Restoration in Chinese Adult Population: Findings from the 4th National Oral Health Survey

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Objective: *To investigate the status of tooth loss and denture restoration in Chinese adults, analyse the changing trend and provide fundamental data for oral health policy.*

Methods: *According to the protocol of the 4th National Oral Health Survey, a multistage stratified random cluster-sampling method was used to enrol adult subjects aged 35 to 44, 55 to 64 and 65 to 74 years in all 31 provinces, municipalities and autonomous regions of the mainland of China. The status of tooth loss and denture restoration was investigated. SPSS20.0 software was used for statistics analysis.*

Results: *Among the 13,464 subjects investigated, 13.8% had complete dentition, 84.4% had dentition defects, and 1.8% was edentulous. Urban subjects showed a significantly higher proportion of complete dentition than those in rural ($P = 0.02$), and males showed the statistically higher proportion of complete dentition than females ($P = 0.01$). The mean of remaining teeth was 26.1 ± 6.90, which in urban areas was significantly higher than in rural areas ($P < 0.01$). The means of remaining teeth were 29.6 ± 2.3, 26.3 ± 6.1, and 22.5 ± 8.7 in the 35 to 44, 55 to 64 and 65 to 74 age groups, respectively. The detection rate of fixed partial dentures (FPD) was statistically higher in urban than in rural areas and in males than that in females ($P < 0.01$). The detection rate of removable partial dentures (RPD) was statistically higher in urban areas than in rural locations ($P < 0.01$). However, the detection rates of irregular denture and unrepair of tooth loss were both significantly lower in urban than in rural areas ($P < 0.01$). The rate of restoration of tooth loss was 41.6% in Chinese adults.*

Conclusion: *Although the tooth loss and denture restoration status recorded in the survey was improved compared with the results of 10 years ago, more efforts need to be made on strengthening oral health promotion, particularly for elderly people and those living in rural areas.*

Key words: *Chinese adults, denture restoration, oral health survey, tooth loss, the 4th National Oral Health Survey*

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Many studies have shown that tooth loss increases with age[1,2]. In China, as the ageing trend of the population had become more obvious, the impact of tooth loss on elderly people's quality of life is becoming serious. As one of the most common oral diseases, tooth loss, mainly including dentition defects and the edentulous, could impact not only on the oral function but also social and psychological activities[3,4]. Oral health goal "8020", which was proposed by Japan and respected by the World Health Organization (WHO), suggests that 80-year-old people should have at least 20 natural teeth[5-7]. Hence, the problem of tooth loss had become one of the most urgent problems for the elderly in China.

To investigate the status of tooth loss and denture restoration for adults in different age groups in China, three National Oral Health Surveys in 1983, 1995 and 2005 respectively were conducted. With rapid development of social economy in the past 10 years, oral health status should have improved because of the adjustment and improvement of dietary structure, nutrition condition, physics and psycho-sociological development[8-10], as well as from government support. Therefore, the 4th National Oral Health Survey was conducted in China from 2015 to 2016.

The present study aims to investigate the status of tooth loss and denture restoration in Chinese adults, thus providing new clinical reference data for oral health promotion to the country's adults and providing relevant policy basis for the government.

Materials and methods

Study design

This study was part of the 4th National Oral Health Survey of China, conducted in 2015 and 2016. Briefly, a multistage stratified random cluster-sampling method was used in all 31 provinces, municipalities and autonomous regions of the mainland of China, and the Probability Proportionate to Size Sampling (PPS sampling method) was used to randomly select subjects. A stratified design method was adopted in age, location (urban or rural areas) and gender (male or female) to ensure a balanced population. The Oral Health Survey project was approved by the Stomatological Ethics Committee of the Chinese Stomatological Association (Approval no. 2014-003).

Data collections

Each of the four investigation sites in every province should complete data collection within 1 month, which included an oral health examination and a questionnaire.

According to oral disease diagnosis standards from the WHO oral health survey basic methods (5th edition)[11], the research focused on two aspects.

Firstly, it focused on the status of tooth loss, including tooth loss classification: complete dentition, dentition defect and the edentulous and remaining number of teeth. The third molar was included in this situation. The status of 32 remaining teeth was recorded as complete dentition, the status of 1 to 31 remaining teeth represented a dentition defect, and no remaining teeth was edentulous.

Secondly, it looked at the status of denture restoration. The status of restorations of dentures was divided into implant dentures, fixed partial dentures (FPD), removable partial dentures (RPD), complete dentures (dentures of half jaw were included), irregular dentures, and unrepaired tooth loss. Moreover, the restoration rate of tooth loss is relevant to the number of adults with tooth loss in which the third molars were excluded.

Data analysis

SPSS20.0 software (SPSS, Chicago, Illinois) was used for data statistics analysis and the normal distribution test. The data of tooth loss was presented as skewness distribution. Data of tooth loss and denture detection

Table 1 Age, region and gender distribution characteristics of the Chinese adult subjects.

	Urban		Rural		Male		Female		Total	
	N	%	N	%	N	%	N	%	N	%
35 to 44 years	2,239	50.8	2,171	49.2	2,197	49.8	2,213	50.2	**4,410**	**32.8**
55 to 64 years	2,342	50.7	2,281	49.3	2,292	49.6	2,331	50.4	**4,623**	**34.3**
65 to 74 years	2,247	50.7	2,184	49.3	2,222	50.1	2,209	49.9	**4,431**	**32.9**
Total	**6,828**	**50.7**	**6,636**	**49.3**	**6,711**	**49.8**	**6,753**	**50.2**	**13,464**	**100**

Table 2 The status of tooth loss in Chinese adult subjects.

Age			N	Proportion of tooth loss classification (%)			Mean of remaining teeth		Group for number remaining teeth	
				Complete dentition	Dentition defect	The edentulous	x	s	0-19(%)	20-32(%)
35 to 74 years	Total		13,464	13.8	84.4	1.8	26.1	6.90	12.4	87.6
	Area	Urban	6,828	14.0	84.5	1.5	26.4	6.58	11.4	88.6
		Rural	6,636	13.7	84.1	2.2	25.9	7.21	13.5	86.5
		P		0.02*			0.00*		0.00*	
	Gender	Male	6,711	14.8	83.4	1.9	26.1	7.04	12.8	87.2
		Female	6,753	12.9	85.3	1.8	26.2	6.76	12.1	87.9
		P		0.01*			0.66		0.12	
35 to 44 years	Total		4,410	24.5	75.5	0.0	29.6	2.30	0.5	99.5
	Area	Urban	2,239	24.0	76.0	0.0	29.6	2.22	0.4	99.6
		Rural	2,171	25.1	74.9	0.0	29.6	2.38	0.6	99.4
		P		0.42			0.67		0.4	
	Gender	Male	2,197	26.5	73.5	0.0	29.7	2.34	0.5	99.5
		Female	2,213	22.5	77.5	0.0	29.5	2.26	0.5	99.5
		P		0.00*			0.01*		1.00	
55 to 64 years	Total		4,623	11.3	87.6	1.1	26.3	6.13	10.6	89.4
	Area	Urban	2,342	12.2	87.0	0.8	26.5	5.88	9.7	90.3
		Rural	2,281	10.4	88.2	1.4	26.1	6.38	11.5	88.5
		P		0.03*			0.02*		0.06	
	Gender	Male	2,292	12.1	86.8	1.1	26.2	6.43	11.3	88.7
		Female	2,331	10.6	88.4	1.1	26.4	5.83	9.9	90.1
		P		0.25			0.14		0.10	
65 to 74 years	Total		4,431	5.8	89.7	4.5	22.5	8.66	26.4	73.6
	Area	Urban	2,247	5.9	90.3	3.8	23.1	8.31	24.2	75.8
		Rural	2,184	5.8	89.1	5.2	22.0	8.98	28.6	71.4
		P		0.81			0.00*		0.00*	
	Gender	Male	2,222	5.9	89.6	4.5	22.5	8.71	26.5	73.5
		Female	2,209	5.8	89.8	4.4	22.5	8.61	26.2	73.8
		P		0.97			0.94		0.84	

*$P < 0.05$

was shown as either a number (percentage) for categorical variables or a mean ± standard deviation (SD) for continuous variables. Group comparisons (i.e. by area or gender) were made using the chi-square test for categorical or nonparametric variables, while the Mann-Whitney U mean test for used for continuous variables. The value of $P < 0.05$ was considered statistically significant.

Results

In total, 13,464 adults were investigated. The age, region and gender distribution characteristics of the subjects are shown in Table 1. The present study covered 372 investigation sites from 62 urban districts and 62 rural counties, which were sampled from the 31 provinces, autonomous regions and municipalities of mainland of China.

The status of tooth loss

The status of tooth loss in Chinese adult subjects of different ages, regions and genders are shown in Table 2. Residents of urban areas have significantly better oral status of dentition completeness and remaining teeth number than that of rural residents ($P <$ or $= 0.01$). Males showed a significantly higher proportion of complete dentition ($P = 0.01$).

In the 35 to 44 and 55 to 64 age groups, the proportion of complete dentition and the mean of remaining teeth were both significantly higher in males than that in females ($P < 0.01$). In the 65 to 74 age group, the proportion of complete dentition was 5.8%, and there was no significant difference between urban and rural areas or gender. The mean of remaining teeth was 22.5 ± 8.66, which in urban areas was statistically higher than that in rural locations ($P < 0.01$), and in this age group, the proportion of the number of more than 20 remaining teeth was 73.6%, which in urban areas was significantly higher than in rural areas ($P < 0.01$).

The status of tooth loss in different tooth positions

The means of tooth loss in all tooth positions for Chinese adults in different age groups are shown in Table 3 and Figure 1 A to C.

Among all the tooth positions, canine showed the lowest mean tooth loss while molars showed the higher. Moreover, the proportion of dentition defect was 52.25% in the maxilla and 47.75% in the mandible. As the ages increased, the means of tooth loss in all tooth positions gradually increased ($P < 0.001$).

Status of denture detection

The status of denture detection and unrepaired tooth loss are shown in Table 4. Generally, among the 13,464 subjects in this survey, the detection rate of fixed partial dentures (FPD), removable partial dentures (RPD) was statistically higher in urban than in rural areas ($P < 0.01$), while, irregular dentures and unrepaired tooth loss were both significantly lower in urban than in rural areas ($P < 0.01$) and the same results across the different age groups.

Proportions of various types of dentures and restoration rates of tooth loss

Status of the proportions of all types of dentures and the restoration rates of tooth loss are shown in Table 5. Among all the dentures detected in this survey, the FPD accounted for the highest proportion with 48.4%. RPD ranked second with 26.7%, complete dentures got a proportion of 5.8%, and the proportion with implant denture was 0.4%. The proportion of irregular dentures was 18.6%. Generally, the rate of restoration of tooth loss was 41.6% in Chinese adult subjects, and the restoration rates of tooth loss in the 35 to 44, 55 to 64 and 65 to 74 age groups respectively were 42.3%, 41.3% and 41.6%.

Table 3 Means of tooth loss in different tooth positions for Chinese adults.

	Position	Incisor	Lateral incisor	Canine	First premolar	Second premolar	First molar	Second molar	Third molar
35 to 44 years	Maxilla	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.6
	Mandible	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.5
55 to 64 years	Maxilla	0.2	0.2	0.1	0.2	0.3	0.4	0.4	0.7
	Mandible	0.2	0.2	0.1	0.1	0.2	0.4	0.5	0.6
65 to 74 years	Maxilla	0.4	0.4	0.3	0.5	0.6	0.7	0.8	0.8
	Mandible	0.5	0.4	0.2	0.3	0.4	0.7	0.7	0.7

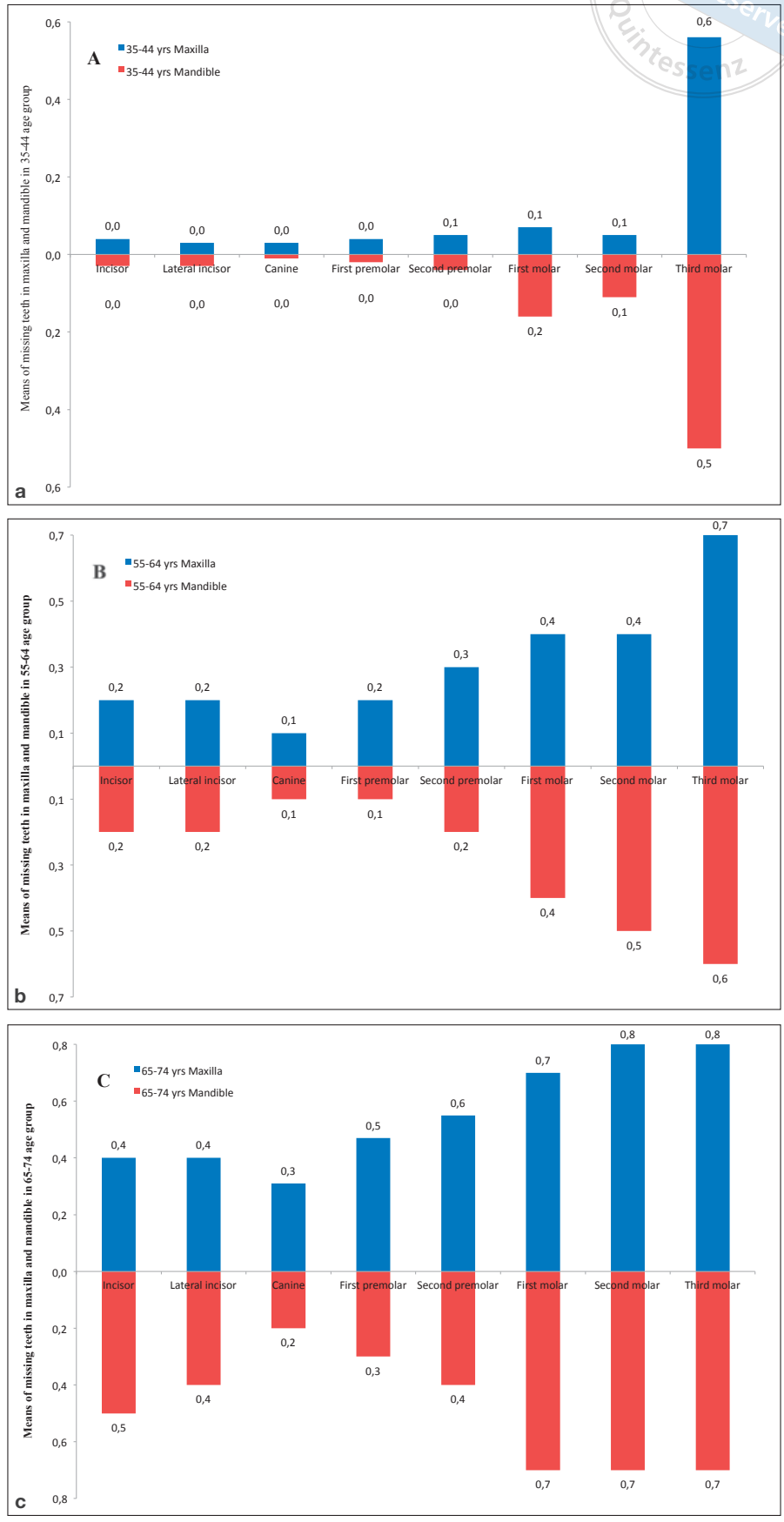

Fig 1 **(A)** Means of missing teeth in maxilla and mandible in the 35 to 44 age group; **(B)** Mean of missing teeth in maxilla and mandible in the 55 to 64 age group; **(C)** Mean of missing teeth in maxilla and mandible in the 65 to 74 age group.

Table 4 Status of denture detection and unrepaired tooth loss in Chinese adult subjects.

Age			N	Rate of Detection (%)					
				Implant denture	Fixed partial denture	Removable partial denture	Complete denture	Irregular denture	Unrepair of tooth loss
35 to 74 years	Total		13,464	0.2	22.3	12.3	2.7	8.6	35.2
	Area	Urban	6,828	0.2	23.7	13.6	2.5	6.9	32.6
		Rural	6,636	0.1	20.9	11.0	2.9	10.4	37.8
		P		0.22	0.00*	0.00*	0.13	0.00*	0.00*
	Gender	Male	6,711	0.2	19.7	12.1	2.7	8.9	35.4
		Female	6,753	0.2	24.9	12.5	2.7	8.3	34.9
		P		0.98	0.00*	0.46	0.96	0.22	0.47
35 to 44 years	Total		4,410	0.2	15.9	2.8	0.9	3.0	18.6
	Area	Urban	2,239	0.2	17.1	3.0	1.0	2.1	16.5
		Rural	2,171	0.1	14.6	2.6	0.7	4.0	20.8
		P		0.33	0.02*	0.42	0.13	0.00*	0.00*
	Gender	Male	2,197	0.1	13.0	2.7	0.7	3.0	18.3
		Female	2,213	0.2	18.7	2.9	1.0	3.0	18.9
		P		0.57	0.00*	0.72	0.40	0.86	0.59
55 to 64 years	Total		4,623	0.1	24.6	13.6	1.9	9.6	38.9
	Area	Urban	2,342	0.1	25.5	14.6	1.5	7.5	36.7
		Rural	2,281	0.0	23.7	12.5	2.4	11.8	41.1
		P		0.63	0.16	0.04*	0.02*	0.00*	0.00*
	Gender	Male	2,292	0.2	21.5	13.7	1.9	9.9	40.1
		Female	2,331	0.0	27.7	13.5	1.9	9.3	37.7
		P		0.06	0.00*	0.90	0.92	0.45	0.10
65 to 74 years	Total		4,431	0.3	26.3	20.4	5.3	13.1	47.7
	Area	Urban	2,247	0.4	28.4	23.0	4.9	10.9	44.2
		Rural	2,184	0.2	24.1	17.7	5.7	15.2	51.3
		P		0.37	0.00*	0.00*	0.28	0.00*	0.00*
	Gender	Male	2,222	0.2	24.5	19.7	5.4	13.5	47.6
		Female	2,209	0.4	28.1	21.1	5.2	12.6	47.8
		P		0.34	0.00*	0.28	0.79	0.35	0.60

*$P < 0.05$; Denture of half jaw was included in the complete denture.

Table 5 Proportions of types of denture, restoration rate of tooth loss in Chinese adults.

Age			Proportions of various types of denture (%)					Numbers of adults with tooth loss*	Numbers of adults with unrepair of tooth loss	Restoration rates of tooth loss (%) **
			Implant denture	Fixed partial denture	Removable partial denture	Complete denture	Irregular denture			
35 to 74 years	Total		0.4	48.4	26.7	5.8	18.6	8,105	4,733	41.6
	Area	Urban	0.5	50.6	29.0	5.3	14.6	4,054	2,223	45.2
		Rural	0.3	46.1	24.3	6.4	23.0	4,051	2,510	38.0
	Gender	Male	0.4	45.3	27.8	6.1	20.4	4,026	2,379	40.9
		Female	0.4	51.3	25.8	5.5	17.1	4,079	2,354	42.3
35 to 44 years	Total		0.7	69.9	12.5	3.6	13.4	1,424	821	42.3
	Area	Urban	1.0	72.8	12.9	4.4	8.9	714	369	48.3
		Rural	0.4	66.6	12.0	2.7	18.3	710	452	36.3
	Gender	Male	0.7	66.2	13.9	3.5	15.7	679	402	40.8
		Female	0.7	72.6	11.4	3.7	11.6	745	419	43.8
55 to 64 years	Total		0.2	49.5	27.3	3.8	19.3	3,061	1,798	41.3
	Area	Urban	0.3	51.9	29.7	2.9	15.2	1,517	860	43.3
		Rural	0.1	47.0	24.8	4.7	23.4	1,544	938	39.2
	Gender	Male	0.4	45.6	29.0	4.0	21.1	1,547	919	40.6
		Female	0.0	52.9	25.8	3.7	17.7	1,514	879	41.9
65 to 74 years	Total		0.5	40.2	31.2	8.1	20.0	3,620	2,114	41.6
	Area	Urban	0.6	42.0	33.9	7.3	16.2	1,823	994	45.5
		Rural	0.4	38.3	28.1	9.0	24.2	1,797	1,120	37.7
	Gender	Male	0.4	38.6	31.1	8.5	21.4	1,800	1,058	41.2
		Female	0.6	41.7	31.3	7.7	18.7	1,820	1,056	42.0

* Number of adults with tooth loss: the third molars were excluded.
** Restoration rates of tooth loss (%) = 1- (number of adults with unrepair of tooth loss/number of adults with tooth loss) × 100%

Discussion

China is an ageing country and tooth loss in adults increases as they age, which significantly affects the quality of life[12]. Access to adequate oral healthcare is important, especially in ageing populations[13]. Tooth loss is one of the most important symbols to reflect oral health in adults, and the cumulative effect of long life on disease and various social factors[14,15]. This nationwide investigation showed the means of remaining teeth were 29.6 ± 2.3, 26.3 ± 6.1, 22.5 ± 8.7 in the 35 to 44, 55 to 64 and 65 to 74 age groups respectively, and edentulous rates were 0.05%, 4.5% in the 35 to 44 and 65 to 74 age groups respectively. The results showed remarkable improvement compared with the data from the 3rd National Oral Health Survey a decade ago, when the means of remaining teeth were 29.4 and 21.0, and edentulous rates were 0.1% and 6.8% in the 35 to 44 and 65 to 74 age groups.

Oral health goals today propose that 80-year-old people should have at least 20 natural teeth[5-7], Some studies have indicated that physical indices and oral health conditions in all who achieved the 8020 goal were better than the non-achievers[16]. A study in 2015

in Taiwan showed that 83.7% of adults with a mean age of 42.5 ± 12.5 had at least 20 teeth[17]. The mean age of the subjects in the present survey was 56.4 ± 12.4 years old, and 87.6% of them had at least 20 teeth. The proportion of the remaining teeth in the 65 to 74-year-old age group was 73.6%.

The edentulous rate is often regarded as the most important indicator of quality of life for the elderly. A study on global ageing and adult health (SAGE) between 2007 and 2010 showed that the rate of the edentulous for those over the age of 65 was 8.9% in China and 15.3% in India[18]. A 2016 US survey showed the rate of the edentulous in 65 to 74-year-old adults living in rural Colorado was up to 15%[15]. Moreover, according to the global oral database from the WHO[19], the edentulous rate for 65 to 74-year-olds was 46% in the UK, 27% in Denmark, 29% in Sweden[20], and between 14% and 27% in most European countries. The same rate for those aged 60 to 69 years old was 26% in the US. In our study, the edentulous rate of the 65 to 74-year-old age group was only 5.2% for rural adults and 3.8% for those living in urban areas, showing a relatively low edentulous rate in China, which may be related to the fact that many residual roots and residual crowns without conservation value remain unextracted.

The present study showed that the rate of dentition defect and the edentulous, the total mean of tooth loss and the mean of tooth loss in every tooth position all increased as people age, which is consistent with the survey in Halifax[21]. The main causes of tooth loss were caries and periodontal disease[22,23]. As they age people were at an increased risk of systemic disease, as well as having poor oral health, which led to a significantly increased risk of tooth loss[9,24].

Many surveys have reported that the number of remaining teeth for urban citizens was higher than that in rural area, such as adults in Norway, men in Sweden, adults in western Australia, women in Brazil and adults in Ireland[25-28]. The present survey also showed that the number of remaining teeth in 65 to 74 year olds in urban areas was higher than that in rural areas. Many factors contribute to the difference, such as a higher rate of smoking by rural adults, a relatively lower level of education, fewer ways of receiving oral health knowledge, a weak consciousness for occlusal function restoration, an unbalance of diet, and the high cost of restoration payment[28].

With the rapid development of the social economy, the rate of denture restoration for Chinese adults aged 35 to 44 and 65 to 74 years old has increased greatly compared with 10 years ago, especially regarding the fixed partial denture. Adults aged 35 to 44 are more willing to choose a fixed partial denture rather than a removable partial denture because of comfort, therefore, in this age group, the rate of fixed partial denture restoration varied from 7.5% to 14.9%, and the rate of removable partial denture restoration varied from 3.5% to 2.8%. Moreover, compared with 10 years ago, the restoration rate of fixed partial dentures and removable partial dentures nowadays varied from 17.1% to 26.3% and from 14.3% to 20.4%, respectively. In this present study, the proportion of the edentulous was 1.8%, while the detection rate of complete dentures was 2.7%. The reason for this is that the third molars were included when the proportion of the edentulous was calculated, while they were excluded when the detection rate of unrepaired tooth loss was calculated. It was analysed that the conditions and awareness of oral health nowadays in the middle-aged adults was better than 10 years ago, which contributed to a higher level of denture restoration. The numbers of tooth loss increased as people's ages increased, which led to tooth loss that was inconsistent with the indication of fixed partial denture restoration, so the proportion of removable partial denture restoration is gradually increased. The rate of implant denture, fixed partial denture and removable partial denture restoration for urban adults was higher than that those in rural areas, and the rate of complete denture restoration in urban areas was lower than in rural areas. Those above again indicated that the level of tooth loss in rural areas was higher than that in urban areas. Also, the detection rate of irregular dentures was up to 8.6%, and the unrepaired rate of tooth loss was 35.2%, which suggested an understanding of damage caused by tooth loss, especially for the elderly in rural areas, needs to be strengthened, as well as medical conditions being improved.

Conclusion

The current conditions of tooth loss in Chinese adults have improved significantly compared with a decade ago. However, the oral health of 65 to 74-year-olds, especially in rural areas, is unsatisfactory, and the rate of denture restoration is at a low level. Thus, further increased investment on oral health should focus more on preventing oral diseases in the elderly, especially those people living in rural areas.

Conflicts of interest

The authors reported no conflicts of interest related to this study.

Author contribution

Dr Jing GUO analysed the data and prepared the manuscript; Drs Jing Hao BAN and Gang LI analysed the data; Drs Xing WANG, Xi Ping FENG, Bao Jun TAI, De Yu HU, Huan Cai LIN, Bo WANG, Yan SI, Chun Xiao WANG, Wen Sheng RONG, Wei Jian WANG, Shu Guo ZHENG, Xue Nan LIU trained the investigators, designed and supervised the survey; Dr Sheng Chao WANG supervised the study and revised the manuscript.

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