ORIGINAL RESEARCH

Radiotherapy vs surgery for T1-2N0M0 laryngeal squamous cell carcinoma: A population-based and propensity score matching study

Cheng Zhan¹ | Xiaodong Yang¹ | Xinmao Song² | Li Yan²

¹Department of Thoracic Surgery, Zhongshan Hospital, Fudan University, Shanghai, China
²Department of Radiation Oncology, Eye & ENT Hospital, Fudan University, Shanghai, China

Correspondence
Li Yan, Department of Radiation Oncology, Eye & ENT Hospital, Fudan University, Shanghai, China.
Email: yanl13@fudan.edu.cn

Funding information
National Natural Science Foundation of China, Grant/Award Number: 81703023

Abstract
There are conflicting reports about whether radiotherapy or surgery is optimal for early-stage laryngeal squamous cell carcinoma (LSCC), although both have recently been recommended. Patients with T1-2N0M0 LSCC in the population-based SEER database who underwent radiotherapy or surgery were reviewed. Propensity score matching was used to eliminate the baseline variations. After matching, 1913 pairs of patients were included. Overall, patients who received radiotherapy had worse cancer-specific survival than patients with surgery. After stratification, the survival in patients who received radiotherapy was worse with respect to the following characteristics: ≤60 years of age; T1a glottis cancer; well-differentiated tumors; and with married status. In other patients, survival outcomes were similar in patients who received radiotherapy and underwent surgery. Our results indicate that radiotherapy is not preferable in early-stage LSCC patients who are ≤60 years of age, have T1a glottis cancer or well-differentiated tumors, or are married. In other patients, both radiotherapy and surgery are comparable. However, our results cannot be a reference before controlled, prospective trials are performed.

KEYWORDS
laryngeal squamous cell carcinoma, radiotherapy, SEER, surgery

1 | INTRODUCTION

As one of the most common cancers worldwide, laryngeal carcinoma accounts for estimated 160,000 new cases and 90,000 deaths every year, of which >95% are squamous cell carcinomas.¹⁻³ Depending on the disease stage at diagnosis, the primary management strategies for patients with laryngeal squamous cell carcinoma (LSCC) mainly consist of surgery and/or radiotherapy. Although the cure rate for early-stage (T1-2N0M0) LSCC is favorable, and ranges between 60% and 100% in several studies, the optimal treatment strategy has not been determined.⁴ According to the latest NCCN guidelines, surgery or definitive radiotherapy can be used for curing T1-2N0M0 LSCC. Several studies have demonstrated improved survival with radiation over surgery.⁵ Survival benefit in patients with early-stage LSCC undergoing surgery has also been reported in a number of other studies.⁶⁻⁸ Due to the conflicting reports, further exploration of the optimal treatment method for early-stage LSCC is warranted.

The Surveillance, Epidemiology and End Results (SEER) program is a large population-based source for cancer statistics, which gives detailed information on incidence,
prevalence, and survival from specific geographic areas and compiled reports on all of these plus cancer mortality. Using cases in SEER, we attempted to determine whether the radiation or surgery could be an optimal treatment regimen for patients with T1-2N0M0 LSCC in this study. Meantime, propensity score matching was used to reduce bias caused by clinical characteristic variance between groups, which may contribute to the existing conflicting consequences. However, it is noteworthy that our results cannot be a reference before controlled, prospective trials are performed.

2 | METHODS

2.1 | Data selection

SEER (Incidence—SEER 18 Regs Custom Data with additional treatment fields, Nov 2016 Sub, 1973—2014 varying) data were obtained via the SEER*Stat software (version 8.3.4; http://seer.cancer.gov/seerstat/). To acquire sufficient data from the database, the selection process is shown in Figure 1. Briefly, patients with labeled primary sites C32.0-Glottis, C32.1-Supraglottis, C32.2-Subglottis, C32.3-Laryngeal cartilage, C32.8-Overlapping lesion of larynx, or C32.9-Larynx NOS were included. Exclusion criteria were as follows: (1) not SCC; (2) without positive histology confirmation; (3) not the first tumor; (4) not stage I or stage II; (4) chemotherapy received; (5) underwent both radiotherapy and surgery; (6) not beam radiation if radiotherapy administered. Conversion from the old version to the seventh AJCC TNM staging system was performed manually. All patients who met the inclusion and exclusion criteria were divided into radiotherapy and surgery groups according to the mode of therapy.

Clinical, pathologic, and sociodemographic characteristics, including age, gender, race, year of diagnosis, state, primary site, grade, T classification, TNM stage, insurance, and marital status at the time of diagnosis, were included in the analyses. Age was categorized by 10 years (≤50, 51-60, 61-70, 71-80, >80 years of age at diagnosis). The LSCC cancer-specific survival status and non-LSCC cancer-specific survival status were followed up for a maximum of 10 years after diagnosis. The survival status was determined by death status, vital status, and other survival indicators. According to the Kaplan-Meier survival curve and log-rank test, the survival differences between groups were then compared.

FIGURE 1  A, Flow diagram of selecting process. B, Mirror histograms of propensity scores for patients with radiotherapy and with surgery. Matched patients are presented in dark color. C, Standardized differences of baseline variables between patients with radiation and with surgery before and after propensity score matching
survival status were extracted from the variables “SEER cause-specific death classification” and “SEER other cause of death classification” in SEER database. The LSCC cancer-specific survival outcome attributed to SCC cancer-specific deaths and survival time was censored at the date of lost follow-up, the last contact data, or the date of death from other causes, whichever occurred first. The non-LSCC cancer-specific survival status was used for competing risk analyses.

2.2 Study design and statistical analysis

Statistical analyses were performed using IBM SPSS Statistics 24.0 (IBM, Inc., Armonk, NY) and R version 3.3.4 (R Foundation for Statistical Computing, Vienna, Austria).

The patients were divided into two groups according to the mode of treatment (radiotherapy vs surgery). The survival analysis was performed using a propensity score matching system to overcome patient selection bias among the baseline variables of the two groups.10,11 Covariates thought to determine the choice of grouped patients were matched in the study as follows: age; gender; race; year of diagnosis; state; site; grade; T classification; TNM stage; insurance; and marital status at the time of diagnosis. The exposure for the propensity model was set as surgery.

Propensity scores were carried out using the “MatchIt” package.10,12,13 Matching results were obtained with the “nearest” matching method, and every case of the surgery group was matched to the control from the radiotherapy group using Wilcoxon and chi-square tests. Univariate and multivariate analyses were performed with the Cox proportional hazards model. Only the variables with a P-value <.05 in the univariate analyses entered into the multivariate analyses, while the multivariate analyses were performed with the backward stepwise (likelihood ratio) method and a threshold 0.10. The survival rates were estimated by the Kaplan-Meier method, and log-rank test was used for comparing survival curves after propensity score matching. Competing risk analyses were performed, as previously reported.15 A two-tailed P-value <.05 was considered statistically significant.

3 RESULTS

3.1 Patient characteristics

As shown in Figure 1A, LSCC accounted for approximately 95.0% (70,684/74,378) of laryngeal tumor cases in 1973-2014 records of SEER database. Patients who were diagnosed between 1973 and 2003 were all excluded in the selection process as there was no TNM stage information of them. After rigorous selection, 7,246 LSCC cases (5,333 radiation vs 1913 surgery) were included in our research. The baseline demographics and clinical characteristics of all participants are summarized in Tables 1 and S1. Compared to the patients who underwent surgery, the patients who received radiotherapy were older (P = .005), had worse tumor differentiation (P = .010), had a higher T classification (P < .001) and TNM stage (P < .001), were more likely to be black (P < .001), and were less likely to have insurance (P < .001). Patients who underwent surgery represented an increasing proportion (P < .001) from 2004 to 2014. These variations in baseline characteristics may have a marked impact on survival outcomes.

After matching based on propensity scores, 1,913 pairs of patients were selected; one-half were treated with radiotherapy and another half underwent surgery. There were no significant differences between the two groups, and all the P values for age, year of diagnosis, state, grade, stage, T classification, and insurance status had been greatly improved (Tables 1 and S1). The absolute values of standardized differences in matched variables were all <10%, suggesting that the variables were well balanced after matching. The matched groups had similar propensity score distributions, and the mirror histograms of propensity scores for patients are shown in Figure 1B,C.

3.2 Survival analyses

The survival outcomes for the two groups of LSCC patients with T1-2N0M0 tumors are shown in Figure 2. Patients who received radiation had a distinctly worse survival when compared with patients who underwent surgery; the five-year cancer-specific survival rates were 83.9 ± 1.1% and 88.5 ± 0.9%, respectively (P = .003; Figure 2A). Competing risk analysis also indicated that the patients who received radiation had a higher risk of LSCC-associated mortality (P = .003), while there was no significant difference in the probabilities of other causes of death (P = .958; Figure 2B).

We further examined the correlation between survival and other parameters. Univariate analyses revealed that age (P < .001), state (P < .001), site (P < .001), grade (P < .001), stage (P < .001), T classification (P < .001), and marital status (P < .001) were statistically significant predictors of LSCC-specific survival in addition to therapy, as shown in Tables 2 and S2. No significant difference was demonstrated for gender (P = .572), race (P = .188), year of diagnosis (P = .286), and insurance status (P = .252). Based on multivariate analysis, therapy (P = .003), age (P < .001), grade (P = .016), T classification (P < .001), and marital status (P < .001) remained independent prognostic predictors for LSCC patients. The variables, site (P = .190) and stage (P = .636), were not significant predictors of survival based
on multivariate analysis because they were not independent from the T classification.

To better characterize the impact of therapeutic approaches on survival of LSCC patients, we stratified the matched patients by variables which were significant based on multivariable analysis. As Figures 3 and S1 show, in patients ≤60 years of age, survival in the radiotherapy group was significantly worse than that of the surgery group. In patients >60 years of age, however, there was no significant difference in survival between the radiotherapy and surgery approaches.
groups. The survival curves were almost overlapping, especially in patients >70 years of age.

In the recent TNM stage system of laryngeal cancer, T1 classification of glottis cancer is divided into T1a, T1b, and T1 not specified. In our analyses, we found that only patients with stage T1a glottic cancer who underwent surgery had superior survival to radiotherapy, while there was no significant difference in T1b and T1 not specified glottic cancer, as shown in Figures 4 and S2. Neither T1 nor T2 supraglottis and subglottis squamous cell carcinomas had significant differences in survival. With respect to differentiation stage, radiotherapy had a comparable survival as surgery in moderately differentiated, poorly or undifferentiated tumors, but not in well-differentiated LSCC patients (Figures 5 and S3).

Interestingly, our analyses showed that surgery had a preferable survival in patients who were married when diagnosed (Figure S4); however, in divorced, single, separated, widowed, or unmarried patients, there were no differences in survival between the radiotherapy and surgery groups.

As shown in Figures S1-S4, the results of competing risk analyses further validated the findings mentioned above after the fully consideration of other death causes.

In all, radiotherapy resulted in a significantly worse survival in LSCC patients with the following characteristics: ≤60 years of age, T1a glottis cancer, well-differentiated tumors, or married (patients with either one characteristic accounted for 85.4% (6188/7246) of all T1-2N0M0 LSCC patients in our cohort). Radiotherapy was not inferior to surgery for the treatment of all other LSCC patients.

4 | DISCUSSION

In this study, we compared the survival of 7246 patients with early-stage LSCC who underwent radiotherapy and surgery. Overall, our study indicated a hypothesis that patients with T1a stage of glottic cancer who were ≤60 years of age, married, or with well-differentiated tumors treated with radiotherapy had worse survival outcomes than patients treated with surgery.

The present study had several limitations that should be noted. First, because the SEER database did not provide detailed information, we could not calculate the influence of factors, such as radiation technology, radiation dose, and surgery regimens. Different surgical or radiotherapy techniques have been adopted in the different institutions, which have great impact on patients’ survival. Second, in this analysis, we only focused on treatment mortality but not life quality as the data of life quality were not included in SEER database. Third, the patients included were from the USA; thus, the results might not be applicable to other populations. The last but not least, although the SEER database is population based and offers excellent follow-up records, our study was retrospective and prospective studies with a larger randomized study cohort are needed to further validate our results.

Our study was based on the data obtained from SEER, a population-based database. Population-based studies may be misinterpreted as they provide comparative survival curves similar to curves found in reports of phase III trials. In fact, population-based data should not be taken as reference studies for clinical decisions, because many biases may obscure their conclusions. In the case of the present study, it is clear from the data before matching that the two populations of patients treated with radiation or with surgery are not prognostically similar, with clear disadvantages for the radiation population.

Megwalu et al\textsuperscript{16} reported that patients with early-stage laryngeal cancer treated with surgery have better survival outcomes than patients treated with radiotherapy. Our analyses revealed that patients with radiotherapy were older, had worse differentiated tumors, had higher-stage tumors, were more likely to be black, and were less likely to have insurance. These variations in baseline characteristics may have a marked impact on survival outcomes. In the current study, we used propensity score matching to eliminate the potential bias caused by the variations in baseline characteristics, while all matched values were well balanced and radiotherapy

FIGURE 2 Survival analyses for patients with radiotherapy and with surgery. A, Kaplan-Meier method; B, competing risk analysis
obtained comparable survival outcomes in a number of patients. Propensity score matching has been frequently applied, and it is expected to play an increasingly important role in future clinical analyses.\textsuperscript{17-19} It is a useful statistical tool to generate hypotheses, but by no means may be taken as a substitute for proper randomization. In addition, a competing risk model was used in the current study to avoid the occurrence of cancer-specific deaths hindered by other deaths.\textsuperscript{15}
The optimal treatment for elderly people with LSCC is not well defined. In the current study, for laryngeal patients >60 years of age, radiotherapy produced comparable survival outcomes compared with surgery. Our results indicated that radiation therapy was closely effective in elderly LSCC patients.
Among LSCCs, glottic cancer is the most common subtype, accounting for 80% of LSCC patients in the current study. Several studies have concluded that surgery is associated with a higher survival in patients with LSCCs, while there are a number of studies that have reported the opposite results; however, most of these studies were based

**FIGURE 4** Survival analyses for patients with radiotherapy and with surgery stratified by T stage after matching. A, T1a; B, T1b; C, T1NOS; D, T1; and E, T2. T1a, T1b, and T1NOS are subsets of glottis cancer.
FIGURE 5  Survival analyses for patients with radiotherapy and with surgery stratified by differentiation after matching. A, Well differentiated; B, moderately differentiated; C, poorly or undifferentiated; and D, differentiation unknown.
on <100 patients. In a large meta-analysis that included 562 participants treated with laser surgery and 706 participants treated with radiotherapy, the pooled analysis showed that laser surgery significantly improved the overall survival of patients with T1 glottic carcinoma group. In the current study, surgery yielded better survival than radiotherapy in patients with T1a stage glottis SCC, but not T1b, T1 not specified, or T2 stages. Our analysis showed that there is no statistically significant association between the mode of treatment and survival of early-stage supra- and subglottic SCC, which is consistent with a previous report. The number of patients with T1-2N0M0 subglottic cancer in our study was limited, perhaps because the vast majority of patients with subglottic cancer present with a locally advanced stage.

Previous reports have revealed that patients with poorly differentiated LSCC fared less well than patients with better differentiated tumors. In the current study, we also found that the grade of differentiation significantly influenced survival based on univariate and multivariate analyses. Compared to more differentiated cancer cells, less differentiated cells reproduce more and have a diminished ability to repair sublethal damage caused by radiotherapy, which will be inherited through cell division, thus accumulating damage to cancer cells. As a result, cells either die or reproduce more slowly. Perhaps this attribute is why LSCC surgery is superior to radiotherapy in patients with well-differentiated tumors, but the survival is comparable in patients with moderately differentiated, poorly differentiated, or undifferentiated LSCC who undergo surgery or receive radiotherapy.

In the current study, we showed that marital status had a significant impact on the prognosis of LSCC patients as previously reported. Inverso et al also reported that marriage had a protective effect against metastatic presentation of laryngeal cancers. Our results showed that surgery had a better survival rate for married patients, while the survival of unmarried patients was similar whether treated with surgery and radiotherapy.

In our study, we only focused on treatment mortality but not voice outcomes or larynx preservations as these data were not recorded in SEER database. In a recent meta-analysis, Huang et al reported that patients with radiotherapy may have the advantage of increased maximum phonation time and decreased fundamental frequency compared with patients undergoing laser surgery in T1a glottis cancer. However, Du et al reported that the acoustic voice analysis parameters of Fo values were significantly lower in radiotherapy group than those in laser surgery group in patients with early glottic cancer. Huang et al also reported that laser surgery may benefit from increased larynx preservation compared with radiotherapy. Now, there are still lacks of studies focused on the voice outcomes or larynx preservation of supraglottis or sublarynx cancer. More trials are still needed.

5 | CONCLUSION

Our results indicate a hypothesis that radiotherapy is not a preferable option in early-stage LSCC patients who are ≤60 years of age, have T1a glottis cancer or well-differentiated tumors, or are married. In all other patients with early-stage LSCC, radiotherapy will yield comparable survival outcomes. However, as the information of radiation and surgery from SEER database is not detailed enough, the study results cannot be a reference before controlled, prospective trials are performed.

ACKNOWLEDGMENTS

This work was supported by the National Natural Science Foundation of China (Grant No. 81703023) (http://www.nsfc.gov.cn/). We would like to thank International Science Editing Co. for editing the language.

CONFLICT OF INTEREST

None declared.

ETHICS STATEMENT

Ethics approval was exempted by the Ethics Committee of the Eye & ENT Hospital of Fudan University (Shanghai, China), as the SEER is a publicly available database, and data extracted from SEER were identified as nonhuman study.

ORCID

Cheng Zhan http://orcid.org/0000-0001-8745-9276
Li Yan http://orcid.org/0000-0002-0697-7838

REFERENCES

1. Tang WJ, Tao L, Lu LM, Tang D, Shi XL. Role of T helper 17 cytokines in the tumour immune inflammation response of patients with laryngeal squamous cell carcinoma. *Oncol Lett*. 2017;14:561-568.
2. Marioni G, Marchese-Ragona R, Cartei G, Marchese F, Staffieri A. Current opinion in diagnosis and treatment of laryngeal carcinoma. *Cancer Treat Rev*. 2006;32:504-515.
3. Torre LA, Bray F, Siegel RL, Ferlay J, Lortet-Tieulent J, Jemal A. Global cancer statistics, 2015. *CA Cancer J Clin*. 2015;65:87-108.
4. Winquist E, Aghassi C, Meyers BM, Yoo J, Chan KK. Systemic therapy in the curative treatment of head and neck squamous cell cancer: a systematic review. *J Otolaryngol Head Neck Surg*. 2017;46:29.
5. Shelan M, Anschez L, Schubert AD, et al. T1-2 glottic cancer treated with radiotherapy and/or surgery. *Strahlenther Onkol*. 2017;193:995-1004.
6. De Virgilio A, Bussu F, De Vincentiis M. Evidence-based review of treatment options for patients with glottic cancer. Acta Otorhinolaryngol Ital. 2012;32:256-257.

7. Remmelts AJ, Hoebers PJ, Kloop WM, Balm AJ, Hamming-Vrieze O, van den Brekel MW. Evaluation of lasersurgery and radiotherapy as treatment modalities in early stage laryngeal carcinoma: tumour outcome and quality of voice. Eur Arch Otorhinolaryngol. 2013;270:2079-2087.

8. Khan MK, Koyfman SA, Hunter GK, Reddy CA, Saxton JP. Definitive radiotherapy for early (T1-T2) glottic squamous cell carcinoma: a 20 year Cleveland Clinic experience. Radiat Oncol. 2012;7:193.

9. Chen JJ, Stessin A, Christos P, Wernicke AG, Nori D, Parashar P. Differences in survival outcome between stage I and stage II glottic cancer: A SEER-based analysis. Laryngoscope. 2015;125:2093-2098.

10. Biondi A, Santocchi P, Pennefri F, Santullo F, D’Ugo D, Persiani R. Totally laparoscopic right colectomy versus laparoscopically assisted right colectomy: a propensity score analysis. Surg Endosc. 2017;31:5275-5282.

11. Yang X, Sun F, Chen L, et al. Prognostic value of visceral pleural invasion in non-small cell lung cancer: A propensity score matching study based on the SEER registry. J Surg Oncol. 2017;116:398-406.

12. Newgard CD, Hedges JR, Arthur M, Mullins RJ. Advanced statistics: the propensity score–a method for estimating treatment effect in observational research. Acad Emerg Med. 2004;11:953-961.

13. Zhang Z. Propensity score method: a non-parametric technique to reduce model dependence. Ann Transl Med. 2017;5:7.

14. Austin PC. Balance diagnostics for comparing the distribution of baseline covariates between treatment groups in propensity-score matched samples. Stat Med. 2009;28:3083-3107.

15. Scrucca L, Santucci A, Aversa F. Competing risk analysis using R: an easy guide for clinicians. Bone Marrow Transplant. 2007;40:381-387.

16. Megwalu UC, Panossian H. Survival outcomes in early stage laryngeal cancer. Anticancer Res. 2016;36:2903-2907.

17. Stokes WA, Stumpf PK, Jones BL, et al. Patterns of fractionation for patients with T2N0M0 glottic larynx cancer undergoing definitive radiotherapy in the United States. Oral Oncol. 2017;72:110-116.

18. Stokes WA, Abbott D, Phan A, Raben D, Lanning RM, Karam SD. Patterns of care for patients with early-stage glottic cancer undergoing definitive radiation therapy: a national cancer database analysis. Int J Radiat Oncol Biol Phys. 2017;98:1014-1021.

19. Bledsoe TJ, Park HS, Stahl JM, et al. Hypofractionated radiotherapy for patients with early-stage glottic cancer: patterns of care and survival. J Natl Cancer Inst. 2017;109:djx042.

20. Peters TT, van der Laan BF, Plaat BE, Wedman J, Langendijk JA, Halmos GB. The impact of comorbidity on treatment-related side effects in older patients with laryngeal cancer. Oral Oncol. 2011;47:56-61.

21. Ahmed J, Ibrahim ASG, Freedman LM, Rosow DE. Oncologic outcomes of KTP laser surgery versus radiation for T1 glottic carcinoma. Laryngoscope. 2017.

22. Alkan U, Nachalon Y, Shkedy Y, Yaniv D, Shwerio J, Popovtizer A. T1 squamous cell carcinoma of the glottis with anterior commissure involvement: Radiotherapy versus transoral laser microsurgery. Head Neck. 2017;39:1101-1105.

23. De Santis RJ, Poon I, Lee J, Karam I, Enepekides DJ, Higgins KM. Comparison of survival between radiation therapy and trans-oral laser microsurgery for early glottic cancer patients; a retrospective cohort study. J Otolaryngol Head Neck Surg. 2016;45:42.

24. Peng Z, Li Y, Jin L, et al. Retrospective analysis of therapeutic effect and prognostic factors on early glottic carcinoma. Photodiagnosis Photodyn Ther. 2016;15:167-171.

25. Mo HL, Li J, Yang X, et al. Transoral laser microsurgery versus radiotherapy for T1 glottic carcinoma: a systematic review and meta-analysis. Lasers Med Sci. 2017;32:461-467.

26. Liu YH, Du ZW. Management of clinically negative nodes (N0) in supraglottic laryngeal carcinoma: a systematic review. Genet Mol Res. 2016;15.

27. Motiee LM, Amirzargar B, Amali A, et al. Rate of occult cervical lymph node involvement in supraglottic squamous cell carcinoma. Iran J Otorhinolaryngol. 2017;29:133-136.

28. Mendenhall WM, Amdor RJ, Morris CG, Hinerman RW. T1-T2N0 squamous cell carcinoma of the glottic larynx treated with radiation therapy. J Clin Oncol. 2001;19:4029-4036.

29. Chen P, Yu W, Huang J, et al. Matched-pair analysis of survival in patients with poorly differentiated versus well-differentiated glottic squamous cell carcinoma. Oncotarget. 2017;8:14770-14776.

30. Cairo MS, Jordan CT, Maley CC, et al. NCI first International Workshop on the biology, prevention, and treatment of relapse after allogeneic hematopoietic stem cell transplantation: report from the committee on the biological considerations of hematological relapse following allogeneic stem cell transplantation unrelated to graft-versus-tumor effects: state of the science. Biol Blood Marrow Transplant. 2010;16:709-728.

31. Megwalu UC, Sikora AG. Survival outcomes in advanced laryngeal cancer. JAMA Otolaryngol Head Neck Surg. 2014;140:855-860.

32. Inverso G, Mahal BA, Aizer AA, Donoff RB, Chau NG, Haddad RI. Marital status and head and neck cancer outcomes. Cancer. 2015;121:1273-1278.

33. Huang G, Luo M, Zhang J, Liu H. The voice quality after laser surgery versus radiotherapy of T1a glottic carcinoma: systematic review and meta-analysis. Onco Targets Ther. 2017;10:2403-2410.

34. Du G, Liu C, Yu W, et al. Voice outcomes after laser surgery vs. radiotherapy of early glottic carcinoma: a meta-analysis. Int J Clin Exp Med. 2015;8:17206-17213.

35. Huang G, Luo M, Zhang J, Liu H. Laser surgery versus radiotherapy for T1a glottic carcinoma: a meta-analysis of oncologic outcomes. Acta Otolaryngol. 2017;137:1204-1209.

SUPPORTING INFORMATION

Additional supplemental material may be found online in the Supporting Information section at the end of the article.

How to cite this article: Zhan C, Yang X, Song X, Yan L. Radiotherapy vs surgery for T1-2N0M0 laryngeal squamous cell carcinoma: A population-based and propensity score matching study. Cancer Med. 2018;7:2837–2847. https://doi.org/10.1002/cam4.1525